TWO INDUSTRIAL COHORTS: FACTORS ASSOCIATED WITH OBESITY AND CHOLESTEROL AT BASELINE AND FOLLOW-UP

by

Ulrike Ott

A dissertation submitted to the faculty of
The University of Utah
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Public Health

Department of Family and Preventive Medicine

The University of Utah

August 2014

The University of Utah Graduate School

STATEMENT OF DISSERTATION APPROVAL

The following faculty members served as the supervisory committee chair and members for the dissertation of Ulrike Ott.

Dates at right indicate the members' approval of the dissertation.

Joseph B. Stanford, Chair 4/24/2014
Date Approved

Maureen A. Murtaugh, Member 4/24/2014
Date Approved

Jessica L.J. Greenwood, Member 4/24/2014
Date Approved

Lisa H. Gren, Member 4/24/2014
Date Approved

Kurt T. Hegmann, Member 4/24/2014
Date Approved

The dissertation has also been approved by Stephen C. Alder Chair of the Department/School/College of Family and Preventive Medicine and by David B. Kieda, Dean of The Graduate School.

ABSTRACT

Among the many health conditions that impact the health of workers are obesity and elevated total cholesterol. Considering the well demonstrated impacts obesity and increased TC levels have on occupational injuries and illnesses, as well as obesity-related health care costs for employers, we aim to address the paucity of literature regarding production workers in this regard. This dissertation uses data from two, multicenter occupational cohorts of production workers to address the current status of these health factors in this population, factors associated with these conditions, and readiness of production workers to reduce weight and total cholesterol. The prevalence of obesity (50.2%) among production workers is greater than is reported for the U.S. adult population (35.7%), and is twice as high as a recently reported prevalence for U.S. workers (27.7%). Considering an even lower prevalence of 22.5% for obesity in the state of Utah, these production workers represent an important target population for weight loss interventions. Results showed that most of the reported associations with increases in weight and TC levels are amenable to interventions and may be a target for workplace intervention programs.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Among the many health conditions that impact the health of workers are obesity and elevated total cholesterol. This dissertation uses data from two, multicenter occupational cohorts of production workers to address the current status of these health factors in this population, factors associated with these conditions, and readiness of production workers to reduce weight and total cholesterol. This introduction reviews the medical literature on the prevalence and impact of these two health conditions, particularly among production workers. It also reviews the behavioral theory used in this research to address potential readiness for health behavior change related to these health conditions.

Obesity

In 2009-2010, 35.5% of U.S. adults were obese.[1, 2] Obesity-related medical costs for U.S. adults have been estimated by the CDC at $147 billion in 2008, with each obese adult having medical costs on average that were $1,429 higher than for a normal weight adult.[3] Obesity ($30.0 \leq BMI \leq 34.9$ kg/m^2) was also associated with 46% increased workers' compensation costs compared to normal weight ($BMI \leq 24.9$ kg/m^2). [4] Unadjusted costs were reported to be $5208 for workers with a BMI≥40 kg/m^2 as compared to $1991 for normal weight workers.[4] Beyond medical costs, being overweight (BMI 25.0-29.9 kg/m^2) has been found to predict sick leave episodes lasting longer than 7 days. [5-7]Obesity has also been widely associated with musculoskeletal or joint-related pain in the feet[8], knees[9-14], back[7, 15-18], shoulders[19-25], and hands. [14, 26] Additionally, obesity has been associated with an increased risk of occupational injuries. [27, 28] Reported injuries attributed to obesity include sprains, strains, injuries to the lower limb or torso, and injuries due to falls or overexertion. [27-30] Obesity is also associated with job limitations (“restrictions”), especially for jobs with high time and physical demands.[31] Obese workers have difficulty moving to perform job functions due to body size and associated physical limitations.[31] Use of personal protective equipment may also be affected by body weight, including effects on respiratory performance during respiratory use. [32]

Limited research has assessed predictors of obesity among production workers. Two studies assessed operating engineers and offshore oil industry workers, with obesity rates ranging from 7.5%[33] to 44.6%[33, 34]. However, both studies relied on self-reported height and weight to assess BMI.

A study to assess risks of death among Shell Oil Company’s manufacturing and research facilities reported that 37% of employees were obese. [35] Another study analyzed data from a multisite aluminum manufacturing company and reported a combined prevalence of overweight and obesity of 85%. [28] Neither of those studies assessed predictors of obesity. Also, to our knowledge no study has addressed factors associated with changes in body mass index or obesity status in production workers.

Total Cholesterol (TC)

Elevated cholesterol has been associated with workplace absenteeism and health care costs. [36] Henke et al. estimated that cholesterol, aside from weight, blood pressure and glucose, had the greatest impact on total health costs among workers in a manufacturing plant. [4] High risk for cholesterol was also associated with 46% higher medical care costs. [4]

One in every six adults (16.3%) in the United States has high cholesterol (≥240mg/dl). [37] Population-based data on cholesterol status come from the National Health and Nutrition Examination Survey (NHANES), which has been conducted since the early 1960s and is designed to assess the health and nutrition status of adults and children in the United States. [38] The survey has two components including a questionnaire and laboratory examinations. The questionnaire covers demographics, socioeconomic, dietary, and health related questions while the laboratory component entails a detailed blood test including TC, low density lipoprotein (LDL), and high density lipoprotein (HDL), measures.

NHANES data between 1999-2000 to 2005-2006 showed a significant decline in the mean age-adjusted serum cholesterol level for all U.S. adults aged ≥20 years from 204 mg/dl to 199 mg/dl,[39] including from 203 mg/dl to 195 mg/dl for men and from 205 mg/dl to 201mg/dl in women.[39] However, to the best of our knowledge, there are no data available regarding factors associated with change in total cholesterol among production workers.

In addition to the NHANES survey, cholesterol trends are being tracked by the Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is an on-going national telephone survey identifying health conditions and risk behaviors in the United States since 1984. [40] Data are collected monthly in all 50 states. The percentage of people who have had their cholesterol checked within the past 5 years has increased nationally from 67.9% in 1995 to 76.9% in 2009.[41] There has also been an increase in people who have had their cholesterol checked and have been told it was too high, rising from 28.1% in 1995 to 37.4% in 2009.[41]

Transtheoretical Model (TTM)

The Transtheoretical Model (TTM) for behavioral change was developed in 1981 by Prochaska et al. [42-44] and has been widely utilized in the health promotion and education field.[42] It is especially useful as it incorporates concepts from previously developed models such as the Health Belief Model.[45] The model has since been applied to a wide array of behaviors including smoking cessation, exercise behavior, contraceptive use and dietary behavior. [45-52] The model defines change as a process involving progress through a series of stages.[45] People in the precontemplation stage are typically not thinking about change and often do not recognize the negative consequences associated with their behavior. They may be underinformed or uninformed about negative health consequences due to their behavior.[44-46] People in the contemplation stage are weighing the costs and benefits of change and have a stated intention to change within the next 6 months. Weighing pros and cons can result in chronic contemplation or behavioral procrastination. [44-46] People in the preparation stage intend to take action in the next month and have a plan of action. [46] People have made lifestyle modifications in the action stage and have done so for 6 months. [46] Lastly, people who have managed to uphold their new behavior over time are considered to be in the maintenance stage.[46]

The TTM is useful for health professionals as it provides additional information about workers receptiveness for specific workplace prevention strategies. By identifying a patient's stage of change process, health professionals are able to tailor possible intervention programs and help them move along the stages of change. To the best of our knowledge, there are no data available regarding perceptions of weight status and intentions for diet and weight change among production workers.

Objectives

The National Occupational Research Agenda (NORA) has developed strategic goals designed to address the most prevalent occupational safety and health issues and to promote the greatest opportunities for reduction and/or elimination of occupational illnesses in the workplace.[53] One of the strategic goals is to reduce the number and severity of musculoskeletal disorders among manufacturing sector workers.[53]

Considering the well demonstrated impacts obesity and increased TC levels have on occupational injuries and illnesses, as well as obesity-related health care costs for employers, we aim to address the paucity of literature regarding production workers in this regard.

Therefore, the main objectives of this research are to: 1) report measured BMI, health risk indicators, and demographic characteristics among two production working populations, 2) ascertain characteristics associated with obesity, 3) ascertain characteristics associated with changes in weight and TC over years of follow-up, 4) report the readiness to change dietary intake and weight, and 5) ascertain differences between self-perceived and measured BMI.

References

1. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA* 2012;307:491-497.

2. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009-2010. *NCHS Data Brief* 2012:1-8.

3. Chronic Disease Prevention and Health Promotion: Obesity. Available at: http://www.cdc.gov/chronicdisease/resources/publications/aag/obesity.htm. Accessed: February 4, 2013.

4. Henke RM, Carls GS, Short ME, et al. The relationship between health risks and health and productivity costs among employees at Pepsi Bottling Group. *J Occup Environ Med* 2010;52:519-527.

5. van Duijvenbode DC, Hoozemans MJ, van Poppel MN, Proper KI. The relationship between overweight and obesity, and sick leave: a systematic review. *Int J Obes (Lond)* 2009;33:807-816.

6. Schmier JK, Jones ML, Halpern MT. Cost of obesity in the workplace. *Scandinavian Journal of Work, Environment & Health* 2006;32:5-11.

7. Tubach F, Leclerc A, Landre MF, Pietri-Taleb F. Risk factors for sick leave due to low back pain: a prospective study. *J Occup Environ Med* 2002;44:451-458.

8. Irving DB, Cook JL, Young MA, Menz HB. Obesity and pronated foot type may increase the risk of chronic plantar heel pain: a matched case-control study. *BMC Musculoskeletal Disorders* 2007;8:41.

9. Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. *Osteoarthritis and Cartilage / OARS, Osteoarthritis Research Society* 2010;18:24-33.

10. Wendelboe AM, Hegmann KT, Biggs JJ, et al. Relationships between body mass indices and surgical replacements of knee and hip joints. *Am J Prev Med* 2003;25:290-295.

11. Kohatsu ND, Schurman DJ. Risk factors for the development of osteoarthrosis of the knee. *Clinical Orthopaedics and Related Research* 1990:242-246.

12. Bagge E, Bjelle A, Eden S, Svanborg A. Factors associated with radiographic osteoarthritis: results from the population study 70-year-old people in Goteborg. *The Journal of Rheumatology* 1991;18:1218-1222.

13. Felson DT. The epidemiology of knee osteoarthritis: results from the Framingham Osteoarthritis Study. *Seminars in Arthritis and Rheumatism* 1990;20:42-50.

14. Andersen RE, Crespo CJ, Bartlett SJ, Bathon JM, Fontaine KR. Relationship between body weight gain and significant knee, hip, and back pain in older Americans. *Obesity Research* 2003;11:1159-1162.

15. Heuch I, Hagen K, Zwart JA. Body mass index as a risk factor for developing chronic low back pain: a follow-up in the Nord-Trondelag Health Study. *Spine* 2013;38:133-139.

16. Leino-Arjas P, Solovieva S, Kirjonen J, Reunanen A, Riihimaki H. Cardiovascular risk factors and low-back pain in a long-term follow-up of industrial employees. *Scandinavian Journal of Work, Environment & Health* 2006;32:12-19.

17. Miranda H, Viikari-Juntura E, Punnett L, Riihimaki H. Occupational loading, health behavior and sleep disturbance as predictors of low-back pain. *Scandinavian Journal of Work, Environment & Health* 2008;34:411-419.

18. Van Nieuwenhuyse A, Crombez G, Burdorf A, et al. Physical characteristics of the back are not predictive of low back pain in healthy workers: a prospective study. *BMC Musculoskeletal Disorders* 2009;10:2.

19. Morken T, Moen B, Riise T, et al. Prevalence of musculoskeletal symptoms among aluminium workers. *Occup Med (Lond)* 2000;50:414-421.

20. Silverstein BA, Bao SS, Fan ZJ, et al. Rotator cuff syndrome: personal, work-related psychosocial and physical load factors. *J Occup Environ Med* 2008;50:1062-1076.

21. Miranda H, Viikari-Juntura E, Martikainen R, Takala EP, Riihimaki H. A prospective study of work related factors and physical exercise as predictors of shoulder pain. *Occupational and Environmental Medicine* 2001;58:528-534.

22. Luime JJ, Verhagen AP, Miedema HS, et al. Does this patient have an instability of the shoulder or a labrum lesion? *JAMA* 2004;292:1989-1999.

23. Wendelboe AM, Hegmann KT, Gren LH, Alder SC, White GL, Jr., Lyon JL. Associations between body-mass index and surgery for rotator cuff tendinitis. *The Journal of Bone and Joint Surgery, American Volume* 2004;86-A:743-747.

24. Roquelaure Y, Ha C, Rouillon C, et al. Risk factors for upper-extremity musculoskeletal disorders in the working population. *Arthritis and Rheumatism* 2009;61:1425-1434.

25. Viikari-Juntura E, Shiri R, Solovieva S, et al. Risk factors of atherosclerosis and shoulder pain--is there an association? A systematic review. *European Journal of Pain (London, England)* 2008;12:412-426.

26. Nathan PA, Keniston RC, Myers LD, Meadows KD. Obesity as a risk factor for slowing of sensory conduction of the median nerve in industry. A cross-sectional and longitudinal study involving 429 workers. *J Occup Med* 1992;34:379-383.

27. Janssen I, Bacon E, Pickett W. Obesity and its relationship with occupational injury in the canadian workforce. *Journal of Obesity* 2011;2011:531403.

28. Pollack KM, Sorock GS, Slade MD, et al. Association between body mass index and acute traumatic workplace injury in hourly manufacturing employees. *American Journal of Epidemiology* 2007;166:204-211.

29. Luckhaupt SE, Cohen MA, Li J, Calvert GM. Prevalence of obesity among U.S. Workers and associations with occupational factors. *Am J Prev Med* 2014;46:237-248.

30. Burt S, Deddens JA, Crombie K, Jin Y, Wurzelbacher S, Ramsey J. A prospective study of carpal tunnel syndrome: workplace and individual risk factors. *Occupational and Environmental Medicine* 2013;70:568-574.

31. Gates DM, Succop P, Brehm BJ, Gillespie GL, Sommers BD. Obesity and presenteeism: the impact of body mass index on workplace productivity. *J Occup Environ Med* 2008;50:39-45.

32. Schulte PA, Wagner GR, Ostry A, et al. Work, obesity, and occupational safety and health. *American Journal of Public Health* 2007;97:428-436.

33. Parkes KR. Demographic and lifestyle predictors of body mass index among offshore oil industry workers: cross-sectional and longitudinal findings. *Occup Med (Lond)* 2003;53:213-221.

34. Duffy SA, Cohen KA, Choi SH, McCullagh MC, Noonan D. Predictors of obesity in Michigan operating engineers. *Journal of Community Health* 2012;37:619-625.

35. Tsai SP, Donnelly RP, Wendt JK. Obesity and mortality in a prospective study of a middle-aged industrial population. *J Occup Environ Med* 2006;48:22-27.

36. Bertera RL. The effects of behavioral risks on absenteeism and health-care costs in the workplace. *J Occup Med* 1991;33:1119-1124.

37. Center for Disease Control and Prevention. Cholesterol Facts. 2010. Available at: http://www.cdc.gov/cholesterol/facts.htm. Accessed: 2014, January 25.

38. About the National Health and Nutrition Examination Survey. Available at: http://www.cdc.gov/nchs/nhanes/about_nhanes.htm. Accessed: 2011, May 30.

39. Center for Disease Control and Prevention. QuickStats: Mean Serum Total Cholesterol Level Among Adults Aged >20 Years, by Sex --- National Health and Nutrition Examination Survey (NHANES), United States, 1999--2000 to 2005--2006. *MMWR* 2008;57:153.

40. Behavioral Risk Factor Surveillance System: Turning Information into Health. Available at: http://www.cdc.gov/brfss/index.htm. Accessed: 2011, May 30.

41. Prevalence and Trends Data: Cholesterol Awareness. Available at: http://www.cdc.gov/nchs/data/databriefs/db117.htm. 2012.

42. Grossschadl F, Titze S, Burkert N, Stronegger WJ. Moderate- and vigorous-intensity exercise behaviour according to the Transtheoretical Model: associations with smoking and BMI among Austrian adults. *Wiener Klinische Wochenschrift* 2013;125:270-278.

43. Prochaska JO, DiClemente CC. Stages and processes of self-change of smoking: toward an integrative model of change. *Journal of Consulting and Clinical Psychology* 1983;51:390-395.

44. Prochaska JO, DiClemente CC, Norcross JC. In search of how people change. Applications to addictive behaviors. *The American Psychologist* 1992;47:1102-1114.

45. Zimmerman GL, Olsen CG, Bosworth MF. A 'stages of change' approach to helping patients change behavior. *American Family Physician* 2000;61:1409-1416.

46. Karen Glanz, Barbara K Rimer (Editor), (Editor) FML. *Health Behavior and Health Education: Theory, Research, and Practice*: Published by Jossey-Bass; 2002.

47. De Vet E, De Nooijer J, De Vries NK, Brug J. Do the transtheoretical processes of change predict transitions in stages of change for fruit intake? *Health Education & Behavior: The Official Publication of the Society for Public Health Education* 2008;35:603-618.

48. Kim MS. Exercise stages of change among university students taking fitness and sport skills courses. *Perceptual and Motor Skills* 2010;110:1149-1153.

49. Kong W, Langlois MF, Kamga-Ngande C, Gagnon C, Brown C, Baillargeon JP. Predictors of success to weight-loss intervention program in individuals at high risk for type 2 diabetes. *Diabetes Research and Clinical Practice* 2010;90:147-153.

50. Marcus BH, Rakowski W, Rossi JS. Assessing motivational readiness and decision making for exercise. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association* 1992;11:257-261.

51. Marcus BH, Simkin LR. The stages of exercise behavior. *The Journal of Sports Medicine and Physical Fitness* 1993;33:83-88.

52. Verheijden MW, Van der Veen JE, Bakx JC, et al. Stage-matched nutrition guidance: stages of change and fat consumption in Dutch patients at elevated cardiovascular risk. *Journal of Nutrition Education and Behavior* 2004;36:228-237.

53. National Occupational Research Agenda (NORA). National Manufacturing Agenda. Available at: http://www.cdc.gov/niosh/nora/comment/agendas/manuf/pdfs/ManufJune2010.pdf.

CHAPTER 2

TWO INDUSTRIAL COHORTS: BASELINE CHARACTERISTICS AND FACTORS ASSOCIATED WITH OBESITY

Abstract

Objective

To describe demographic and health characteristics, and factors associated with obesity in two cohorts of production workers.

Methods

Baseline data from two multicenter, prospective occupational cohorts were analyzed. Logistic regression modeling was used to assess associations between worker characteristics and obesity.

Results

The mean age of the combined population was 40.6 (SD=11.7) years. The mean body mass index (BMI) was 29.5 kg/m^2 (SD=6.5). The majority of the combined cohorts was overweight (33.0%) or obese (40.9%). Factors associated with obesity differed

substantially between the two cohorts. Being Asian, currently smoking, and having past alcohol problems decreased the odds of being obese in the distal upper extremity cohort, while being Pacific Islander/Native Hawaiian and married increased the odds of being obese in the low back pain cohort.

Conclusion

Factors associated with obesity differed substantially between the two cohorts. Recognizing factors associated with obesity in specific work settings may provide opportunities for preventive workplace interventions.

Introduction

In 2009-2010, 35.5% of U.S. adults were obese.[1, 2] Differences in adult obesity prevalence include higher levels of obesity among nonhispanic black women (58.5%) and Mexican-American women (44.9%) than for nonhispanic White women (32.2%).[2] The CDC estimates that overall medical costs related to obesity for U.S. adults were $147 billion in 2008. [3] The U.S. economic productivity losses due to obesity are projected to be between $48 billion and $66 billion per year by 2030. [4] In the work setting, a prospective cohort found that employees who were obese (BMI≥30 kg/m^2) were absent longer and more frequently than those of normal weight (BMI 18.5-24.9 kg/m^2). Obese employees were absent 14 days more per year than normal weight employees.[5] These costs extend beyond obesity, as those overweight (BMI 25-29.9 kg/m^2) workers reportedly have more sick leave episodes lasting longer than 7 days than of normal weight workers. [6, 7]

Obese workers have difficulty performing job functions due to body size and associated physical limitations.[8] Obesity has also been widely associated with musculoskeletal or joint-related pain in the feet[9], knees[10-14], back[15-19], shoulders[20-25], and hands. [26, 27] Additionally, obesity has been associated with an increased risk of occupational injuries. [28, 29] Reported injuries attributed to obesity include sprains, strains, injuries to the lower limb or torso, and injuries due to falls or overexertion. [28]

Other health factors also impact the health and associated costs for production workers. One in every six adults (16.3%) has high cholesterol (≥240 mg/dl), [30] which has been associated with workplace absenteeism and health care costs. [31 32] Mean annual illness costs for other behavioral risks per person at risk reportedly include: smoking ($960), overweight ($401), excess alcohol intake ($389), obesity ($400), high blood pressure ($343), and lack of exercise ($130). [31]

Research among production workers has been limited to assessing operating engineers and offshore oil industry workers,[33, 34] with obesity rates ranging from 7.5%[34] to 44.6%.[33] However, both studies relied on self-reported height and weight to assess BMI. Research among Shell Oil Company's manufacturing and research facilities reported that 37% of its employees were obese in a study assessing risk factors for death.[35] Another study analyzed data from a multisite aluminum manufacturing company and reported a combined prevalence for overweight and obesity of 85%. [29] Neither of those studies assessed predictors of obesity among production workers.

Considering the reported impact obesity has on occupational injuries and illnesses as well as obesity-related health care costs for employers, we aim to fill the gap in the literature regarding production workers. This study reports measured BMI, other health risk indicators, and demographic characteristics in this working population upon entry into two large cohort studies of workers' health. We also sought to ascertain characteristics associated with obesity among these populations.

Methods

Data from two multicenter, prospective cohorts (the WISTAH Distal Upper Extremity (DUE) cohort and the BackWorks Low Back Pain (LBP) cohort) were analyzed for this study.[36, 37] Both cohorts were approved by the respective Institutional Review Boards at the participating sites (University of Utah (LBP IRB_00011889, DUE IRB_00010930), University of Wisconsin-Milwaukee (LBP IRB #04.02.049, DUE IRB# 03.02.059), Medical College of Wisconsin (DUE IRB #484.02), and Texas A&M University (LBP IRB #2003-0408). The University of Wisconsin also conducted enrollments in Illinois. Baseline data for these cohorts were collected during serial worksite enrollment sessions conducted between 2002 and 2007. For the purpose of this study, all baseline data were compiled upon the termination of both cohort studies in 2012, then analyzed in 2013. The parent cohort studies have detailed methods papers published elsewhere, thus a brief summary of the methods follows.[36, 37]

Subjects

Subjects were at least 18 years of age and employed at a participating company. Participants were excluded if they could not give informed consent, did not speak either English or Spanish and were planning to retire within 4 years of study enrollment. To improve generalizability of the results, subjects were recruited from 28 diverse production facilities for the LBP cohort and 17 diverse production facilities for the DUE cohort.

Employment settings varied between both cohorts and included e.g., poultry processing, manufacturing and assembly of animal laboratory testing equipment, small engine manufacturing and assembly, small electric motor manufacturing and assembly, commercial lighting assembly and warehousing, electrical generator manufacturing and assembly, metal automotive engine parts manufacturing (three facilities), plastic and rubber automotive engine parts manufacturing and assembly, red meat processing, apparel manufacturing, office work, cabinet manufacturing, airbag manufacturing, light valve assembly, printing operations, and a toilet seat manufacturer.[36, 37]

Measures

At baseline enrollments, workers completed a laptop-administered questionnaire under the supervision of a research assistant. Baseline data included demographics (e.g., age, gender, education level, and race), social history, physical activity and hobbies outside work, tobacco use, psychosocial factors (e.g., depression, job satisfaction, family problems) and past medical history of healthcare provider diagnoses (e.g., diabetes mellitus, high cholesterol, high blood pressure).[36, 37]

Leisure-time physical activity questions addressed 21 specific activities (e.g., walking, baseball). Each of those activities was further queried for the number of months per year, the average number of times per week, and the average number of minutes each activity was performed. A composite of all these activities was calculated and the total reported leisure-time physical activity in mean minutes per week was determined.

Height and weight measurements were measured in stocking feet to calculate body mass indices (BMIs). If weight exceeded 200kg, two scales were used simultaneously and the sum was recorded. BMI <18.5kg/m^2 was classified as underweight, between 18.5 and 24.9 kg/m^2 was classified as normal weight, 25-29.9kg/m^2 was classified as overweight and >30kg/m^2 was classified as obese.

Blood pressure was measured in a seated position after a minimum of 5 minutes of rest using automated cuffs (Omron HEM-780).

In the later phases of enrollments, nonfasting total cholesterol (TC) levels were collected by venipuncture (N=366). Earlier enrollees did not have their TC levels measured due to lack of resources.

In the LBP cohort only, waist and hip circumferences (cm) were measured to calculate waist-hip ratios (WHR) for each participant. A WHR<0.90 was considered normal for men and a WHR<0.85 was considered normal for women.[38]

Data Analyses

All analyses were performed using SAS 9.3 (SAS Institute, Cary, North Carolina). Outliers and missing data were verified by pulling individual charts for each participant if possible. Imputation using the study population mean was used when missing data could not be verified. Less than 0.1% of all data were imputed.

Based on direct observations, a sizable proportion of the LBP cohort have major physical job demands as compared to the DUE cohort. This may have resulted in a high probability that many workers in the LBP cohort have a higher lean muscle mass which may have resulted in a modestly elevated BMI (e.g., increasing someone with otherwise normal weight into overweight). We therefore assessed whether the cohorts act as a confounder between predictor variables and obesity by analyzing stratified data. Results indicated that the cohort itself is a strong confounder and therefore, results are reported separately for each cohort.

Predictor variables were analyzed for normality and skewness. Differences in distributions between both cohorts were determined by using *t*-tests (normal distribution), Wilcoxon-Mann-Whitney (not normally distributed) and chi square analyses. Statistical significance was determined using α level of 0.05. Frequencies, means and standard deviations were used to describe the population.

Pearson's correlation statistics were used to correlate WHR with BMI, which was suspected to be a marker for the dependent variable. Correlation coefficient for the combined cohort was 0.3 and stratified by gender was 0.4 for male and 0.2 for female.

Univariate and multivariate categorical analyses were conducted for each cohort to analyze factors associated with obesity (BMI$\geq$ 30 kg/m^2 compared to BMI$<$30 kg/m^2). Variables were excluded from the multivariate model if they were likely to be an outcome of elevated BMI (diabetes mellitus, high cholesterol). Multivariate logistic regression was conducted to identify which factors were independently associated with obesity. Stepwise backwards regression analyses were performed separately for each cohort. Factors for the multivariate model were retained based on 1) significance in the backwards regression for either cohort ($p<0.05$) and 2) evidence published in other research articles and biological plausibility. The LBP multivariate models was adjusted for: LBP age, gender, race, marital status, education, alcohol problems in the past, tobacco use, physical activity, waist-hip ratio, and depression. The DUE multivariate model was adjusted for the same factors, except for waist-hip ratio.

Results

Of 1,974 total subjects in this study, 857 were enrolled in the LBP cohort and 1,117 in the DUE cohort. Some (n=112) participants were enrolled into both cohort studies. These dual enrollees were analyzed as LBP participants in this report.

In the combined cohort, the mean age was 40.6 (SD=11.7) years (see Tables 1 and 2). The majority of the combined cohort was overweight (33.0%) or obese (40.9%) with a mean BMI of 29.5 (SD=6.5) kg/m^2. Mean BMI and proportion of participants in BMI categories were similar in both cohorts. Both cohorts were also similar regarding prevalences of diabetes mellitus (LBP 4.4% vs. DUE 5.0%), high cholesterol (LBP 18.3% vs. DUE 16.8%), high blood pressure (LBP 14.1% vs. DUE 16.8%), and a history of prior alcohol problems (LBP 5.5% vs. DUE 4.5%).

The cohorts differed statistically in other characteristics. Workers in the LBP cohort were younger than the DUE cohort. There were more females in the DUE cohort (66.7% vs. 36.5%), more White participants (76.5% vs. 51.0%) and fewer Hispanic/Latino workers in the DUE cohort (12.7% vs. 27.3%). The two cohorts also differed somewhat in marital and educational status (Table 1).

LBP participants reported higher levels of physical activity, and higher levels of job satisfaction than DUE participants. DUE participants reported more frequently feeling depressed than LBP participants (Table 1).

Univariate and multivariate categorical analyses were conducted for each cohort to analyze factors associated with obesity. Table 3 shows the results for the LBP cohort. The multivariate LBP model was adjusted for: age, gender, race, education, marital status, smoking, physical activity, WHR, alcohol problems, and depression.

In univariate analyses, age was associated with obesity (ages 30-50 years, OR=1.5, 95% CI=1.1-2.0). After adjusting the model, this association was no longer significant.

Workers who were Pacific Islanders or Native Hawaiians had 5.4 higher odds of being obese compared to those identified as White (OR=5.4, 95% CI=2.6-11.3). This association became more significant after adjusting the model (OR=7.0, 95% CI=3.2-15.6). Asians had decreased odds of being obese compared to Whites in the univariate (OR=0.5, 95% CI=0.2-1.0) as well as the multivariate model (OR=0.5, 95% CI=0.2-1.0).

Being married (OR=1.6, 95% CI=1.0-2.4) or divorced (OR=1.8, 95% CI=1.0-3.1) increased the odds of being obese compared to being single in the LBP cohort. These associations persisted in the multivariate model.

Table 4 shows the results of the univariate and multivariate analyses for factors associated with obesity in the DUE cohort. The multivariate model was adjusted for the same covariates as the model for the LBP cohort.

Overall, results for the DUE cohort showed different predictors for being obese as compared to the LBP cohort. Univariate analyses in the DUE cohort showed that age was associated with obesity (ages >50 years, OR=1.6, 95% CI=1.1-2.3).

Women in the DUE cohort were found to have higher odds of being obese in the univariate model compared to men (OR=1.4, 95% CI=1.1-1.8). This association was no longer significant after adjusting for covariates. Race was not associated with obesity in the DUE cohort. Current smokers were at lower odds of being obese compared to nonsmokers (OR=0.4 95% CI=0.3-0.6).

Workers who “always” were mentally exhausted after work had 2.3 times the odds of being obese compared to those who were “never” mentally exhausted after work (OR=2.3, 95% CI=1.2-4.4, p=0.01). Higher frequency of depressive symptoms was also found to be associated with being obese (“Often”: OR=1.8, 95% CI=1.2-2.6, “Always”: OR=4.4, 95% CI=1.7-11.8). These associations were stronger after adjusting the model for covariates (“Often”: OR=2.0, 95% CI=1.3-3.0, “Always”: OR=4.7, 95% CI=1.7-13.1).

Reported physical activity was not associated with obesity in any of the models. We conducted additional analyses with physical activity by adjusting for estimated metabolic equivalent values[39], but physical activity remained unassociated with obesity.

Discussion

The prevalence of obesity among production workers (40.9%) was greater than estimates of the U.S. adult population (35.7%).[1] The combined prevalence of overweight and obesity of 78% is also greater than the combined prevalence in the U.S. adult population (≥20 years) of 62.9%.[40]

These results suggest the effects of the obesity epidemic on production operation facilities may potentially be disproportionate. [8,9,10-14,15-19,20-25, 26, 27 28, 29]

Yet, characteristics associated with obesity differed between the two cohorts. These differences may be due to higher physical job demands among the LBP cohort such as lifting heavy items and greater ambulatory demands. Participants in the LBP cohort likely have a higher lean muscle mass as compared to the DUE cohort. Univariate models revealed that age was significantly associated with obesity among both cohorts. Among the LBP cohort, multivariate models indicated 1) being Asian and having past alcohol problems decreased the odds of being obese, 2) being Pacific Islander/Native Hawaiian, and being married or divorced increased the odds of being obese. In contrast, univariate models among the DUE cohort revealed that mental exhaustion after work was associated with obesity. Multivariate models indicated that being above the age of 50 years, a smoker (decreased odds) and depression (increased odds) were significantly associated with obesity among the DUE cohort. We believe that age was not associated with obesity due to the increased job physical demands among the LBP cohort as compared to the DUE cohort. Workers in the LBP cohort may be more physically active throughout their employment.

This research found past alcohol problems among the LBP cohort was a protective factor against obesity. Previous research regarding alcohol consumption and obesity reported conflicting results. Light to moderate alcohol consumption may reduce weight, while nondrinkers or heavy drinkers may experience the opposite effect. [33, 43, 44] Women who reported no alcohol use were more likely to be obese than those who consumed 1-3 portions per week.[45]

Results of the DUE cohort are supported by prior literature that smokers are less likely to be obese.[33, 45, 46] Trends were similar in the LBP cohort but did not reach statistical significance. Smoking has been reported to increase the metabolic rate and decrease caloric intake. [33]

This research found strong associations between symptoms of depression and obesity among the DUE cohort but not the LBP cohort. It may be that the relative inactivity of large muscles in the DUE jobs compared with those in the LBP cohort may be contributing to these findings.[51] A prior meta-analysis of 15 longitudinal studies found bidirectional associations between depression and obesity, with obese persons having a 55% increased risk of developing depression, while depressed people had a 58% increased risk of becoming obese. [50] While confirming prior studies, we are unable to determine the direction of these relationships due to the cross sectional research design of this study.

This research filled a gap in the literature and also overcame some of the prior studies' weaknesses. Strengths of this study include: 1) anthropometric measures, 2) multicenter data from four diverse states, 3) recruitment from 45 diverse employment facilities to improve generalizability of the results, 4) computerized data collection methods of questionnaires, and 5) a large sample size.

Several factors limit these findings, including that we could only determine associations due to the cross-sectional study design. Recall bias inherently limits self-reported survey studies. This may particularly affect recall of physical activity participation. Data support that participants heavily over-reported their leisure-time physical activity. Prior evidence suggests that overweight individuals tend to over-estimate or over-report the amount of activity they perform.[52, 53]

Considering the well documented impact of obesity on occupational illnesses, injuries, and overall increasing productivity costs, this research identified target populations in manufacturing for interventions to improve weight and weight related comorbidities. The workplace, therefore, may be an optimal location for workplace prevention programs that target weight loss interventions, with some potential differences needed depending on the physical nature of the manufacturing facilities' jobs.

Conclusion

Both an upper extremity and low back pain cohort among production workers had a higher baseline prevalence of obesity and overweight than that of the general U.S. population. Yet, the factors associated with obesity differed between the cohorts, and may be related to the type of work performed. The high prevalences of obesity in these work settings are concerning as they relate to risks of work-related musculoskeletal injury, as well as obesity related chronic diseases. These results suggest a need for workplace intervention programs for prevention and treatment of obesity that are tailored to the unique characteristics associated with obesity and occupational demands in a particular work setting.

Table 1: Categorical demographic characteristics and self-reported health factors

	LBP Cohort (N=857)		DUE Cohort (N=1117)		P-Value***	Cohorts Combined (N=1974)*	
	N	%	N	%		N	%
Age (Years)					<0.0001		
≤30	256	29.9	205	18.4		461	23.4
>30-≤50	405	47.3	611	54.7		1016	51.5
>50	196	22.9	301	27.0		497	25.2
Gender					<0.0001		
Female	313	36.5	745	66.7		1058	53.6
Male	544	63.5	372	33.3		916	46.6
Race					<0.001		
White	437	51.0	854	76.5		1291	65.4
African American or Black	92	10.7	60	5.4		152	7.7
Asian	46	5.4	21	1.9		67	3.4
Pacific Islander or Native Hawaiian	45	5.3	36	3.2		81	4.1
Native American or Alaskan Native	3	0.4	6	0.5		9	0.5
Hispanic or Latino	234	27.3	140	12.5		374	19.0
Marital Status					0.01		
Never Married (Single)	222	25.9	251	22.5		473	24.0
Married	492	57.4	636	56.9		1128	57.1
Divorced	106	12.4	181	16.2		287	14.5
Separated	26	3.0	21	1.9		47	2.4
Widowed	11	1.3	28	2.5		39	2.0
Education Level					0.002		
8th grade or less	18	2.1	29	2.6		47	2.4

Table 1: continued

	LBP Cohort (N=857)		DUE Cohort (N=1117)		P-Value***	Cohorts Combined (N=1974)*	
	N	%	N	%		N	%
Some high school	87	10.2	89	8.0		176	8.9
High school graduated or GED	436	50.9	656	58.7		1092	55.3
Some college	264	30.8	303	27.1		567	28.7
College graduate (Bachelor's degree or higher)	52	6.1	40	3.6		92	4.7
BMI Category					0.25		
Underweight (BMI < 18.5)	10	1.2	7	0.6		17	0.9
Normal (BMI 18.5–24.9)	207	24.2	291	26.1		498	25.2
Overweight (BMI 25–29.9)	298	34.8	354	31.7		652	33.0
Obese (BMI ≥ 30)	342	39.9	465	41.6		807	40.9
Mean Self-Reported Total Physical Activity Minutes per Week summed					<0.0001		
0 to 240	308	35.9	861	77.1		1169	59.2
240 to 480	207	24.2	175	15.7		382	19.4
More than 480	342	39.9	81	7.3		423	21.4
Tobacco Use					0.0004		
Never	473	55.2	524	46.9		997	50.5
Yes, but I smoked in the past	197	23.0	275	24.6		472	23.9
Yes, currently	187	21.8	318	28.5		505	25.6
Alcohol Problem in the Past					0.30		
Yes	47	5.5	50	4.5		97	4.9
No	810	94.5	1067	95.5		1877	95.1
Diabetes Mellitus**					0.55		
Yes	38	4.4	56	5.0		94	4.8

Table 1: continued

	LBP Cohort (N=857)		DUE Cohort (N=1117)		P-Value***	Cohorts Combined (N=1974)*	
	N	**%**	**N**	**%**		**N**	**%**
No	819	95.6	1061	95.0		1880	95.2
High Cholesterol (>200 mg/dl)**					0.39		
Yes	157	18.3	188	16.8		345	17.5
No	700	81.9	929	83.2		1629	82.5
High Blood Pressure Diagnosis**							
Yes	121	14.1	188	16.8	0.10	309	15.7
No	736	85.9	929	83.2		1665	84.4
How Often do you have Family Problems that Irritate or Bother You					<0.0001		
Never	262	30.6	191	17.1		453	23.0
Seldom	449	52.4	652	58.4		1101	55.8
Often	112	13.1	207	18.5		319	16.2
Always	34	4.0	67	6.0		101	5.1
How Often do you feel Down, Blue or Depressed					<0.0001		
Never	310	36.2	263	23.6		573	29.0
Seldom	415	48.4	633	56.7		1048	53.1
Often	114	13.3	200	17.9		314	15.9
Always	18	2.1	21	1.9		39	2.0
Mentally exhausted after work					<0.0001		
Never	197	23.0	299	26.8		496	25.1
Seldom	496	57.9	558	50.0		1054	53.4
Often	126	14.7	218	19.5		344	17.4
Always	38	4.4	42	3.8		80	4.1

Table 1: continued

	LBP Cohort (N=857)		DUE Cohort (N=1117)		P-Value***	Cohorts Combined (N=1974)*	
	N	%	N	%		N	%
Satisfied with your job******					<0.0001		
Very satisfied	272	31.7	231	20.7		503	25.5
Satisfied	533	62.2	599	53.6		1132	57.4
Neither satisfied nor dissatisfied	4	0.5	220	19.7		224	11.4
Dissatisfied	17	2.0	58	5.2		75	3.8
Very dissatisfied	31	3.6	9	0.8		40	2.0

*112 participants were enrolled in both cohorts and considered enrolled in the LBP cohort for thesis analysis

**Recall questions: "Have you ever been diagnosed by a health professional?"

***T-Test to determine if the distribution is the same or different across both cohorts

****“A little satisfied” and “Somewhat satisfied” responses from the DUE cohort were categorized as “Satisfied”

Table 2: Continuous measures of health factors

	LBP Cohort (N=857)			DUE Cohort (N=1117)				Cohorts Combined (N=1974)		
	Mean ± SD	**Median**	**Range**	**Mean (SD)**	**Median**	**Range**	**P-Value****	**Mean (SD)**	**Median**	**Range**
Age (Years)	38.9±11.9	38.2	18.3-69	41.6±11.3	43.4	18.3-68.5	<0.0001	40.6±11.7	41.1	18.3-69.0
BMI (kg/m2)	29.3±6.0	28.3	11-61.5	29.7±6.7	28.6	16.2-58.6	0.2	29.5±6.5	28.5	11.0-61.5
Diastolic Blood Pressure (mm Hg)	78.3±10.8	78	43-147	79.7±10.6	80	54-125	0.003	79.1±10.7	79	43-147
Systolic Blood Pressure (mm Hg)	128.6±17.1	128	74-235	127.9±17	126	90-204	0.3	128.2±17	127	74-235
Self-Reported Physical Activity (min/week)	503.4±569.4	352.5	0-7035	159.9±217.3	91.3	0-2698.3	<0.0001	309±443.1	170	0-7035
Waist-Hip Ratio	0.9±0.1	0.9	0.5-1.6	Not assessed				Not assessed		
***	**LBP Cohort (N=237)**			**DUE Cohort (N=129)**			**P-Value**	**Cohorts Combined (N=366)**		
Total Cholesterol (mg/dl)*	186.9±35.8	185	88-308	194.3±36.7	194	104-303	0.06	189.6±36.2	188	88-308
Low Density Lipoprotein (mg/dl)*	101.8±28.5	102.9	14-186	105±31.6	103	29-240	0.3	102.9±29.6	102.9	14-240
High Density Lipoprotein (mg/dl)*	46.3±12.6	45	21-85	54.6±15.1	52	27-108	<0.0001	49.2±14.1	47	21-108

*Cholesterol measurements were taken from 336 study participants at baseline enrollments

**T-Test to determine if the distribution is the same or different across both cohorts

***Mean HDL, LDL, and TC for LBP cohort (Male: 42.7mg/dl, 101.9mg/dl, 187.1mg/dl; Female: 53.2mg/dl, 101.5mg/dl, 186.6mg/dl)

Table 3: Univariate and multivariate analyses for factors associated with obesity among the LBP cohort (BMI≥30 compared to BMI<30)

	LBP (N=857)							
	Univariate				Multivariate[1]			
		95% CI				95% CI		
	OR	Lower	Upper	P-Value	OR	Lower	Upper	P-Value
Age								
<=30	1.0		Reference		1.0		Reference	
>30-50	1.5	1.1	2.0	0.02	1.2	0.8	1.8	0.4
>50	1.3	0.9	2.0	0.1	0.9	0.5	1.4	0.6
Gender								
Male	1.0		Reference		1.0		Reference	
Female	1.1	0.8	1.4	0.7	0.9	0.6	1.2	0.5
Race								
White	1.0		Reference		1.0		Reference	
African American or Black	1.3	0.8	2.1	0.7	1.5	0.9	2.5	0.1
Asian	0.5	0.2	1.0	0.003	0.4	0.2	1.0	0.04
Pacific Islander or Native Hawaiian	5.4	2.6	11.3	0.0003	7.0	3.2	15.6	<0.0001
Native American or Alaskan Native	3.1	0.3	34.6	0.5	2.5	0.2	31.4	0.5
Hispanic or Latino	0.8	0.6	1.1	0.03	0.7	0.5	1.1	0.1
Education Level								
8th grade or less	1.0		Reference		1.0		Reference	
Some high school	0.9	0.3	2.6	0.9	1.3	0.4	4.1	0.6

Table 3: continued

	LBP (N=857)							
	Univariate				Multivariate[1]			
		95% CI				95% CI		
	OR	**Lower**	**Upper**	**P-Value**	**OR**	**Lower**	**Upper**	**P-Value**
High school graduated or GED	0.9	0.3	2.2	0.8	0.9	0.3	2.7	0.9
Some college	0.7	0.3	1.9	0.5	0.8	0.3	2.4	0.7
College graduate (Bachelor's degree or higher)	0.8	0.3	2.5	0.8	1.0	0.3	3.2	1.0
Marital Status								
Never Married (Single)	1.0		Reference		1.0		Reference	
Married	1.8	1.3	2.5	0.001	1.6	1.0	2.4	0.03
Divorced	1.7	1.1	2.8	0.02	1.8	1.0	3.1	0.05
Separated	0.7	0.3	1.8	0.4	0.6	0.2	1.7	0.3
Widowed	1.3	0.4	4.6	0.7	1.2	0.3	5.5	0.8
Tobacco Use								
Never	1.0		Reference		1.0		Reference	
Yes, but I smoked in the past	1.0	0.7	1.3	0.8	1.1	0.7	1.6	0.8
Yes, currently	0.7	0.5	1.1	0.1	0.8	0.5	1.2	0.3
Mean Total Physical Activity Minutes per Week summed								
0 to 240	1.0		Reference		1.0		Reference	
240 to 480	0.8	0.6	1.2	0.2	0.8	0.5	1.1	0.2
More than 480	1.1	0.8	1.6	0.4	1.1	0.8	1.6	0.6
Waist-Hip Ratio**								
Normal	1.0		Reference		1.0		Reference	

Table 3: continued

	LBP (N=857)							
	Univariate				Multivariate[1]			
		95% CI				95% CI		
	OR	Lower	Upper	P-Value	OR	Lower	Upper	P-Value
Abnormal	4.5	3.2	6.4	<0.0001	4.6	3.2	6.8	<0.0001
Alcohol Problem in the Past								
Yes	0.5	0.3	1.0	0.04	0.4	0.2	0.8	0.02
No	1.0		Reference		1.0		Reference	
Diabetes Mellitus*								
Yes	2.7	1.4	5.3	0.0004				
No	1.0		Reference					
High Cholesterol (>200 mg/dl)*								
Yes	1.2	0.9	1.7	0.3				
No	1.0		Reference					
How Often do you feel Down, Blue or Depressed								
Never	1.0		Reference		1.0		Reference	
Seldom	0.7	0.6	1.0	0.1	0.8	0.6	1.2	0.3
Often	0.9	0.6	1.3	0.5	1.0	0.6	1.6	1.0
Always	0.8	0.3	2.2	0.7	0.9	0.3	2.7	0.8
How Often do you have Family Problems that Irritate or Bother You								
Never	1.0		Reference					
Seldom	1.0	0.7	1.4	1.0				

Table 3: continued

	LBP (N=857)							
	Univariate				Multivariate[1]			
		95% CI				95% CI		
	OR	Lower	Upper	P-Value	OR	Lower	Upper	P-Value
Often	1.1	0.7	1.7	0.8				
Always	1.1	0.5	2.2	0.9				
Mentally exhausted after work								
Never	1.0		Reference					
Seldom	0.9	0.7	1.3	0.7				
Often	1.0	0.6	1.5	0.9				
Always	0.7	0.4	1.5	0.4				
Satisfied with your job*								
Very satisfied	1.0		Reference					
Satisfied	0.8	0.6	1.1	0.1				
Neither satisfied nor dissatisfied	1.3	0.2	9.4	0.8				
Dissatisfied	0.7	0.3	2.0	0.5				
Very dissatisfied	1.1	0.5	2.3	0.9				

*"A little satisfied" and "Somewhat satisfied" responses from the LBP cohort were categorized as "Satisfied"
**Abnormal is defined as a waist–hip ratio above 0.90 for males and above 0.85 for females
***Recall questions: "Have you ever been diagnosed by a health professional?" Both health characteristics have been excluded from multivariate analyses as they are a result of obesity rather than a predictor.
[1] Multivariate Model was adjusted for: Age, Gender, Race, Marital Status, Education, Alcohol Problems in the Past, Tobacco Use, Physical Activity, Waist-Hip Ratio, Depression

Table 4: Univariate and multivariate analyses for factors associated with obesity among the DUE cohort (N=1117) (BMI≥ 30 compared to BMI<30)

	Univariate				Multivariate[1]			
		95% CI				95% CI		
	OR	Lower	Upper	P-Value	OR	Lower	Upper	P-Value
Age								
<=30	1.0	Reference			1.0	Reference		
>30-50	1.3	0.9	1.8	0.2	1.3	0.9	1.8	0.2
>50	1.6	1.1	2.3	0.01	1.6	1.0	2.4	0.04
Gender								
Male	1.0	Reference			1.0	Reference		
Female	1.4	1.1	1.8	0.02	1.2	0.9	1.5	0.3
Race								
White	1.0	Reference			1.0	Reference		
African American or Black	1.1	0.6	1.8	0.9	1.2	0.7	2.1	0.5
Asian	0.4	0.2	1.2	0.1	0.4	0.1	1.1	0.1
Pacific Islander or Native Hawaiian	1.7	0.9	3.5	0.1	1.3	0.7	2.7	0.4
Native American or Alaskan Native	1.4	0.3	7.1	0.7	1.3	0.2	6.7	0.8
Hispanic or Latino	1.0	0.7	1.4	0.9	0.9	0.6	1.3	0.4
Education Level								
8th grade or less	1.0	Reference			1.0	Reference		
Some high school	0.7	0.3	1.7	0.5	0.9	0.3	2.1	0.7
High school graduated or GED	0.9	0.4	1.8	0.7	1.0	0.5	2.2	1.0
Some college	1.0	0.5	2.1	1.0	1.1	0.5	2.5	0.8
College graduate (Bachelor's degree or higher)	0.7	0.2	1.8	0.4	0.6	0.2	1.6	0.3
Marital Status								
Never Married (Single)	1.0	Reference			1.0	Reference		
Married	1.2	0.9	1.6	0.2	0.9	0.7	1.3	0.6

Table 4: continued

	DUE (N=1117)							
	Univariate				Multivariate[1]			
		95% CI				95% CI		
	OR	Lower	Upper	P-Value	OR	Lower	Upper	P-Value
Divorced	0.9	0.6	1.3	0.5	0.7	0.4	1.1	0.1
Separated	2.1	0.8	5.1	0.1	1.8	0.7	4.6	0.2
Widowed	1.4	0.6	3.0	0.5	0.9	0.4	2.1	0.8
Tobacco Use								
Never	1.0		Reference		1.0		Reference	
Yes, but I smoked in the past	0.8	0.6	1.0	0.1	0.7	0.5	1.0	0.05
Yes, currently	0.4	0.3	0.6	<0.0001	0.4	0.3	0.6	<0.0001
Mean Total Physical Activity Minutes per Week summed								
0 to 240	1.0		Reference		1.0		Reference	
240 to 480	0.9	0.6	1.2	0.4	0.9	0.6	1.3	0.6
More than 480	0.8	0.5	1.3	0.5	0.9	0.6	1.5	0.8
Alcohol Problem in the Past								
Yes	0.6	0.4	1.2	0.2	0.7	0.4	1.4	0.3
No	1.0		Reference		1.0		Reference	
Diabetes Mellitus*								
Yes	4.5	2.4	8.4	<0.0001				
No	1.0		Reference					
High Cholesterol (>200 mg/dl)*								
Yes	2.0	1.5	2.7	<0.0001				
No	1.0		Reference					

Table 4: continued

	Univariate				Multivariate[1]			
		95% CI				95% CI		
	OR	Lower	Upper	P-Value	OR	Lower	Upper	P-Value
How Often do you feel Down, Blue or Depressed								
Never	1.0		Reference		1.0		Reference	
Seldom	1.2	0.9	1.6	0.3	1.3	0.9	1.8	0.1
Often	1.8	1.2	2.6	0.003	2.0	1.3	3.0	0.001
Always	4.4	1.7	11.8	0.003	4.7	1.7	13.1	0.003
How Often do you have Family Problems that Irritate or Bother You								
Never	1.0		Reference					
Seldom	1.0	0.7	1.4	0.9				
Often	1.2	0.8	1.8	0.4				
Always	1.6	0.9	2.7	0.1				
Mentally exhausted after work								
Never	1.0		Reference					
Seldom	1.2	0.9	1.5	0.3				
Often	1.0	0.7	1.4	1.0				
Always	2.3	1.2	4.4	0.01				
Satisfied with your job**								
Very satisfied	1.0		Reference					
Satisfied	1.0	0.8	1.4	0.8				
Neither satisfied nor dissatisfied	1.0	0.7	1.4	0.8				
Dissatisfied	1.2	0.7	2.2	0.5				
Very dissatisfied	0.4	0.1	2.0	0.3				

*Recall questions: "Have you ever been diagnosed by a health professional?" Both health characteristics have been excluded from multivariate analyses as they are a result of obesity rather than a predictor. **"A little satisfied" and "Somewhat satisfied" responses from the DUE cohort were categorized as "Satisfied". [1]Multivariate model was adjusted for: Age, Gender, Race, Marital Status, Education, Alcohol Problems in the Past, Tobacco Use, Physical Activity, Depression

References

1. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009-2010. *NCHS Data Brief* 2012:1-8.

2. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA* 2012;307:491-497.

3. Chronic Disease Prevention and Health Promotion: Obesity. Available at: http://www.cdc.gov/chronicdisease/resources/publications/aag/obesity.htm. Accessed: February 4, 2013.

4. Trust for America's Health and the Robert Wood Johnson Foundation. F as in Fat: How Obesity Threatens America's Future. [Serial online]. 2012;2013(September). Available from: http://healthyamericans.org/report/100/.

5. Jans MP, van den Heuvel SG, Hildebrandt VH, Bongers PM. Overweight and obesity as predictors of absenteeism in the working population of the Netherlands. *J Occup Environ Med* 2007;49:975-980.

6. van Duijvenbode DC, Hoozemans MJ, van Poppel MN, Proper KI. The relationship between overweight and obesity, and sick leave: a systematic review. *Int J Obes (Lond)* 2009;33:807-816.

7. Schmier JK, Jones ML, Halpern MT. Cost of obesity in the workplace. *Scandinavian Journal of Work, Environment & Health* 2006;32:5-11.

8. Gates DM, Succop P, Brehm BJ, Gillespie GL, Sommers BD. Obesity and presenteeism: the impact of body mass index on workplace productivity. *J Occup Environ Med* 2008;50:39-45.

9. Irving DB, Cook JL, Young MA, Menz HB. Obesity and pronated foot type may increase the risk of chronic plantar heel pain: a matched case-control study. *BMC Musculoskeletal Disorders* 2007;8:41.

10. Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. *Osteoarthritis and Cartilage / OARS, Osteoarthritis Research Society* 2010;18:24-33.

11. Wendelboe AM, Hegmann KT, Biggs JJ, et al. Relationships between body mass indices and surgical replacements of knee and hip joints. *Am J Prev Med* 2003;25:290-295.

12. Kohatsu ND, Schurman DJ. Risk factors for the development of osteoarthrosis of the knee. *Clinical Orthopaedics and Related Research* 1990:242-246.

13. Bagge E, Bjelle A, Eden S, Svanborg A. Factors associated with radiographic osteoarthritis: results from the population study 70-year-old people in Goteborg. *The Journal of Rheumatology* 1991;18:1218-1222.

14. Felson DT. The epidemiology of knee osteoarthritis: results from the Framingham Osteoarthritis Study. *Seminars in Arthritis and Rheumatism* 1990;20:42-50.

15. Heuch I, Hagen K, Zwart JA. Body mass index as a risk factor for developing chronic low back pain: a follow-up in the Nord-Trondelag Health Study. *Spine* 2013;38:133-139.

16. Leino-Arjas P, Solovieva S, Kirjonen J, Reunanen A, Riihimaki H. Cardiovascular risk factors and low-back pain in a long-term follow-up of industrial employees. *Scandinavian Journal of Work, Environment & Health* 2006;32:12-19.

17. Miranda H, Viikari-Juntura E, Punnett L, Riihimaki H. Occupational loading, health behavior and sleep disturbance as predictors of low-back pain. *Scandinavian Journal of Work, Environment & Health* 2008;34:411-419.

18. Tubach F, Leclerc A, Landre MF, Pietri-Taleb F. Risk factors for sick leave due to low back pain: a prospective study. *J Occup Environ Med* 2002;44:451-458.

19. Van Nieuwenhuyse A, Crombez G, Burdorf A, et al. Physical characteristics of the back are not predictive of low back pain in healthy workers: a prospective study. *BMC Musculoskeletal Disorders* 2009;10:2.

20. Morken T, Moen B, Riise T, et al. Prevalence of musculoskeletal symptoms among aluminium workers. *Occup Med (Lond)* 2000;50:414-421.

21. Silverstein BA, Bao SS, Fan ZJ, et al. Rotator cuff syndrome: personal, work-related psychosocial and physical load factors. *J Occup Environ Med* 2008;50:1062-1076.

22. Miranda H, Viikari-Juntura E, Martikainen R, Takala EP, Riihimaki H. A prospective study of work related factors and physical exercise

as predictors of shoulder pain. *Occupational and Environmental Medicine* 2001;58:528-534.

23. Luime JJ, Verhagen AP, Miedema HS, et al. Does this patient have an instability of the shoulder or a labrum lesion? *JAMA* 2004;292:1989-1999.

24. Wendelboe AM, Hegmann KT, Gren LH, Alder SC, White GL, Jr., Lyon JL. Associations between body-mass index and surgery for rotator cuff tendinitis. *The Journal of Bone and Joint Surgery, American Volume* 2004;86-A:743-747.

25. Roquelaure Y, Ha C, Rouillon C, et al. Risk factors for upper-extremity musculoskeletal disorders in the working population. *Arthritis and Rheumatism* 2009;61:1425-1434.

26. Nathan PA, Keniston RC, Myers LD, Meadows KD. Obesity as a risk factor for slowing of sensory conduction of the median nerve in industry. A cross-sectional and longitudinal study involving 429 workers. *J Occup Med* 1992;34:379-383.

27. Andersen RE, Crespo CJ, Bartlett SJ, Bathon JM, Fontaine KR. Relationship between body weight gain and significant knee, hip, and back pain in older Americans. *Obesity Research* 2003;11:1159-1162.

28. Janssen I, Bacon E, Pickett W. Obesity and its relationship with occupational injury in the canadian workforce. *Journal of Obesity* 2011;2011:531403.

29. Pollack KM, Sorock GS, Slade MD, et al. Association between body mass index and acute traumatic workplace injury in hourly manufacturing employees. *American Journal of Epidemiology* 2007;166:204-211.

30. Center for Disease Control and Prevention. Cholesterol Facts. 2010. Available at: http://www.cdc.gov/nchs/data/databriefs/db117.htm. 2012.

31. Bertera RL. The effects of behavioral risks on absenteeism and health-care costs in the workplace. *J Occup Med* 1991;33:1119-1124.

32. Henke RM, Carls GS, Short ME, et al. The relationship between health risks and health and productivity costs among employees at Pepsi Bottling Group. *J Occup Environ Med* 2010;52:519-527.

33. Duffy SA, Cohen KA, Choi SH, McCullagh MC, Noonan D. Predictors of obesity in Michigan Operating Engineers. *Journal of Community Health* 2012;37:619-625.

34. Parkes KR. Demographic and lifestyle predictors of body mass index among offshore oil industry workers: cross-sectional and longitudinal findings. *Occup Med (Lond)* 2003;53:213-221.

35. Tsai SP, Donnelly RP, Wendt JK. Obesity and mortality in a prospective study of a middle-aged industrial population. *J Occup Environ Med* 2006;48:22-27.

36. Garg A, Hegmann KT, Moore JS, et al. Study protocol title: a prospective cohort study of low back pain. *BMC Musculoskeletal Disorders* 2013;14:84.

37. Garg A, Hegmann KT, Wertsch JJ, et al. The WISTAH hand study: a prospective cohort study of distal upper extremity musculoskeletal disorders. *BMC Musculoskeletal Disorders* 2012;13:90.

38. World Health Organization. Waist Circumference and Waist–Hip Ratio: Report of a WHO Expert Consultation. Geneva, 8–11 December 2008

39. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise* 2000;32:S498-504.

40. Center for Disease Control and Prevention. Fast Stats: Obesity and Overweight. Available at: http://www.cdc.gov/nchs/fastats/overwt.htm. Accessed: November 30, 2013.

41. Employment Status of the Civilian Noninstitutional Population, 1940 to date [Internet]. Available at: http://www.bls.gov/cps/cpsaat01.pdf. Accessed: September 2012.

42. Hymel PA, Loeppke RR, Baase CM, et al. ACOEM Guidance Statement. Workplace health protection and promotion: a new pathway for a healthier--and safer--workforce. *Journal of Occupational and Environmental Medicine/American College of Occupational and Environmental Medicine* 2011;53:695-702.

43. Arif AA, Rohrer JE. Patterns of alcohol drinking and its association with obesity: data from the Third National Health and Nutrition Examination Survey, 1988-1994. *BMC Public Health* 2005;5:126.

44. Rohrer JE, Rohland BM, Denison A, Way A. Frequency of alcohol use and obesity in community medicine patients. *BMC Family Practice* 2005;6:17.

45. Lahti-Koski M, Pietinen P, Heliovaara M, Vartiainen E. Associations of body mass index and obesity with physical activity, food choices, alcohol intake, and smoking in the 1982-1997 FINRISK Studies. *The American Journal of Clinical Nutrition* 2002;75:809-817.

46. Leventhal AM, Mickens L, Dunton GF, Sussman S, Riggs NR, Pentz MA. Tobacco use moderates the association between major depression and obesity. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association* 2010;29:521-528.

47. Blaine B. Does depression cause obesity?: A meta-analysis of longitudinal studies of depression and weight control. *Journal of Health Psychology* 2008;13:1190-1197.

48. Simon GE, Von Korff M, Saunders K, et al. Association between obesity and psychiatric disorders in the US adult population. *Archives of General Psychiatry* 2006;63:824-830.

49. Paeratakul S, White MA, Williamson DA, Ryan DH, Bray GA. Sex, race/ethnicity, socioeconomic status, and BMI in relation to self-perception of overweight. *Obesity Research* 2002;10:345-350.

50. Luppino FS, de Wit LM, Bouvy PF, et al. Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. *Archives of General Psychiatry* 2010;67:220-229.

51. Atlantis E, Baker M. Obesity effects on depression: systematic review of epidemiological studies. *Int J Obes (Lond)* 2008;32:881-891.

52. Jakicic JM, Polley BA, Wing RR. Accuracy of self-reported exercise and the relationship with weight loss in overweight women. *Medicine and Science in Sports and Exercise* 1998;30:634-638.

53. Lichtman SW, Pisarska K, Berman ER, et al. Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. *The New England Journal of Medicine* 1992;327:1893-1898.

CHAPTER 3

ASSOCIATION WITH CHANGES OF WEIGHT AND TOTAL CHOLESTEROL AMONG TWO OCCUPATIONAL COHORTS OVER 10 YEARS

Abstract

Objective

To ascertain worker characteristics associated with changes in body weight and total cholesterol (TC) among two production operation populations.

Methods

We performed descriptive and predictive analysis of questionnaire data and biomedical measurements from two prospective cohort studies. Our key outcomes were changes in weight, and TC over 5-10 years between baseline and exit assessments.

Results

One hundred forty six subjects were analyzed. Increases in weight were associated with belief in being overweight, consuming breakfast <6 times/week and baseline overweight and obesity. Increases in TC levels were associated with female

gender, belief that TC levels were "not good," and feeling depressed.

Conclusion

Most of the reported associations with increases in weight and TC levels are amenable to interventions and may be a target for workplace intervention programs.

Introduction

One in every six adults (16.3%) has high cholesterol (≥240mg/dl) and 35.5% of U.S. adults are obese.[1, 2] Both elevated cholesterol and BMI have been associated with workplace absenteeism and health care costs. [3] Henke et al. estimated that cholesterol, aside from weight, blood pressure and glucose, had the greatest impact on total health costs among workers in a manufacturing plant. [4]

The CDC estimates that overall medical costs related to obesity for U.S. adults were $147 billion in 2008. [5] The U.S. economic productivity losses due to obesity are projected to be between $48 billion to $66 billion per year by 2030. [6] Besides cardiovascular and other effects, obesity has also been associated with musculoskeletal or joint-related pain in the feet[7], knees[8-12], back[13-17], shoulders[18-23], and hands. [24, 25] Additionally, obesity has been associated with an increased risk of occupational injuries. [26-28]

An individual's perceived risk of developing a certain condition is likely essential in motivating behavior.[29, 30] Adults with elevated cholesterol levels or BMI may be more likely to be motivated to alter their lifestyle because of health concerns. Therefore, it appears necessary that adults have an understanding of key health indicators as well as recommended target levels. A study to assess whether better knowledge improves adherence to lifestyle changes in patients with coronary heart disease concluded that "patient education must be formalized and acknowledged as an official part of the health care system."[31] In other words, people who are aware of their TC levels may be more likely to reduce their blood cholesterol levels.

To the best of our knowledge, no prior research has been conducted assessing the changes in TC and weight over time among production workers. Therefore, the goal of this study was to ascertain characteristics associated with changes in weight and TC from baseline enrollments to study completion. We were particularly interested in assessing whether knowledge of TC and BMI levels were associated with changes.

Methods

This research study was nested within the Utah populations of two prospective cohorts (the WISTAH Distal Upper Extremity (DUE) cohort and the BackWorks Low Back Pain (LBP) cohort). [32, 33] Both cohorts were approved by the University of Utah's Institutional Review Board (#s 00010930 and 00011889). Baseline data for these cohorts were collected during worksite enrollments conducted between 2002 and 2007. Additional data were collected during study completion visits in the Spring of 2012 and analyzed in 2013. The parent cohort studies have detailed methods papers published.[32, 33] Thus, a brief summary of the methods follows.

Subjects

Subjects were at least 18 years of age at enrollment and employed at one of eight participating companies in Utah. Participants were excluded if they could not give informed consent, did not speak either English or Spanish and were planning to retire within 4 years of study enrollment. Subjects for this nested study were recruited from five different employment settings in Utah which included: airbag manufacturing, sewing facility, office work, red meat processing, and printing operations.[32, 33] Only a subset of both cohorts had cholesterol measured at baseline and this subset was eligible for the present analysis.

Baseline Measures

At baseline enrollments, workers completed a laptop administered questionnaire under the supervision of a research assistant. Data quantified at baseline included demographics (age, gender, race, marital status, and education level), leisure-time physical activity, tobacco use, psychosocial factors (e.g., depression, job satisfaction, family problems), and health status (e.g., "Have you even been told by a physician that you have high cholesterol (Laboratory test result over 200 mg/dl)").

Questions addressed 21 leisure-time physical activities (e.g., walking, baseball, basketball) and could include additional activities beyond those 21. Each of those activities was further queried for the number of months per year, the average number of times per week, and the average number of minutes each activity was performed. A composite of all these activities was calculated and the total reported leisure-time physical activity in minutes per week was determined.

Height and weight measurements were measured in stocking feet to calculate body mass indices (BMIs). Height was assumed to have not changed appreciably during the study. If weight exceeded 200kg, two scales were used simultaneously and the sum was recorded. BMI $<18.5 kg/m^2$ was classified as underweight, between $18.5\text{-}24.9 kg/m^2$ was classified as normal weight, $25\text{-}29.9 kg/m^2$ was classified as overweight and $>30 kg/m^2$ was classified as obese.

Serum nonfasting TC, LDL, HDL, triglycerides, C-reactive protein, and hemoglobin A1c levels were measured in blood collected by venipuncture.

Blood pressure was measured in a seated position after a minimum of 5 minutes of rest using automated cuffs (Omron HEM-780).

Study participants were informed of their weight and blood pressure results upon completion of baseline enrollments. Immediate feedback regarding those results was provided in writing indicating desired ranges for each of those measures. The results were also explained to each participant by a researcher. A handout was given to each participant which listed the measured systolic and diastolic blood pressure. Recommendations for normal, pre-hypertension, stage 1 hypertension, and stage 2 hypertension were also listed indicating whether a lifestyle modification is encouraged or not. Blood test results were mailed to the participants upon receipt of the blood results from the laboratory. The mailer contained the current classifications and recommendations for adult TC, low density lipoprotein, high density lipoprotein, triglycerides, C - reactive protein, and hemoglobin A1c. Participants were advised to consult with either their healthcare provider if any of the reported values were out of range.

Study Completion Measures

At study completion, participants completed another laptop administered questionnaire. Survey items quantified leisure-time physical activity outside work, and psychosocial factors (e.g., depression, job satisfaction, and family problems) with the same questions as in the baseline questionnaire. It also included items regarding knowledge of BMI, knowledge of TC levels, and fruit and vegetable intake.

Dietary intake questions were included that have been previously developed. [34] Fruit and vegetable intake was assessed by asking "How many times do you typically eat a serving of fruit in one day?" and "How many times do you typically eat a serving of vegetables in one day?" Binary dummy variables were created for both of these variables (<5 vs. ≥ 5).

Breakfast and fast food consumptions were assessed by asking "How many times do you eat restaurant or fast food in a typical week?" and "How many times do you typically eat breakfast in one week (7 days)?" Dummy variables reporting tertiles were created for both breakfast and fast food consumption.

Participants were asked whether they could recall their current TC and BMI (Yes, No). Questions on how study participants perceive their weight and TC were also included. Subjects were asked "Do you think your Total Cholesterol is: Good, Not Good, Unsure?" and "Do you believe you are" Underweight, Normal Weight, Overweight, Obese, Unsure?" Intake of cholesterol-lowering medication was also assessed.

Having received any education (e.g., doctor, the internet, magazines) in weight management, diet, nutrition or physical fitness throughout the study duration was also assessed.

Outcome Variables

Changes in weight were determined by comparing the measured weight at study completion visit with the weight at the baseline visit.

Blood samples were drawn to measure at study completion via finger stick method using the Alere Cholestech LDX system (Alere Inc., Waltham, MA). These data enabled assessment of changes in TC levels throughout the course of the study.

Data Analysis

All analyses were performed using SAS 9.3 (SAS Institute, Cary, NC). Outliers and missing data were verified by pulling individual charts for each participant. Imputation using the study population mean was used when missing data could not be verified. Less than 0.3% of all data were imputed.

Variables were analyzed for normality and skewness. Mean differences for weight and TC changes between baseline enrollments and study completion visits were determined by using a paired *t*-tests (normal distribution) and Wilcoxon signed rank sum test (not normally distributed).

Statistical significance was determined using α level of 0.05. Frequencies, means and standard deviations were used to describe the population.

We assessed the data for attrition bias since a large proportion of our population exited the study. We aimed to determine whether those workers who exited the study have different characteristics than those who completed the study and would have therefore introduced attrition bias. Differences were assessed for demographics (age, gender, race, education, and marital status) by using chi square test analyses. In addition, we assessed differences for our main continuous health outcomes (weight and TC) by using the Wilcoxon-Mann-Whitney test.

Multivariate linear regression was conducted to identify which factors were independently associated with the main outcomes. Factors for the multivariate model were selected based on evidence published in other research articles and biological plausibility. Stepwise backwards regression analyses were performed separately for each outcome.

To investigate whether the relationships between participant characteristics, BMI, and TC would differ between the cohorts, we ran linear regression models including interaction terms between the cohort status (DUE or LBP) and the predictor variables. We used an a priori p-value of 0.1 for significance of each interaction term.

Results

A total of 366 subjects met the baseline inclusion criteria. More than half exited the study for various reasons unrelated to the study, which are detailed in Figure 1 (e.g., leaving employment to take another job, retirement, termination, etc.). Another 38 were lost to follow up at study completion visits. A total of 146 subjects remained in the cohort through study completion and participated in the end of study visits.

At study completion, participants were between ages 35-55 years (n=86, 58.9%) with a mean age of 49.6 (SD=10.6) years. The majority were female (n=74, 50.7%), and White (n=98, 67.1%). Most (n=106, 72.6%) were married and 46.6% (n=68) had a high school degree or GED. More than half of the population was obese (n=84, 57.5%) with a mean BMI of 31.7kg/m^2 (SD=7.4). Only 4.8% (n=7) of the subjects at exit reported knowing their BMI, although 58.9% (n=86) believed themselves to be overweight. Less than 10% reported knowing their TC. Only 57.5% (n=84) of workers consumed ≥5 servings of fruits and vegetables combined per day. (Table 5)

A plurality of the participants (n=65, 45%) had abnormal TC levels (≥200mg/dl) at baseline enrollments. However, 57% (n=37) with abnormal baseline TC levels reported not having been informed about those abnormal levels by a health professional.

Table 6 shows the mean weight and TC comparing baseline measures and study completion measures. The mean TC became significantly lower (194.4±36.3 vs. 182.1±37.8; $P<0.0001$). In contrast, mean weight was significantly higher at study completion (86.9±23.6 vs. 90.5±24.5; $P=0.003$).

Attrition bias analyses indicated that only age significantly differed between those who exited the study and those who completed it ($p<0.0001$). Differences between groups were not found for gender ($p=0.3$), race ($p=0.2$), marital status ($p=0.2$), education ($p=0.3$), weight ($p=0.1$) and TC levels ($p=0.6$).

Associations with weight changes among production workers are shown in Table 7. Workers who believed they were overweight or obese at study completion gained significantly more weight (6.7kg increase, 14.4g increase) compared to those who believed they were of normal weight.

Those who consumed breakfast <6 times per week (the lowest tertile of breakfast consumption) lost 4.4kg ($p=0.05$) as compared to those eating daily breakfasts. No significant associations were found between fast food consumption and weight changes. Reported physical activity at baseline was not associated with weight changes.

Associations with TC changes are reported in Table 8. TC level changes for workers who indicated “always” feeling depressed were significantly higher (112.4 mg/dl, p=0.009) than those who indicated “never.” However, only two workers indicated “always” feeling depressed.

Workers who indicated “often” having family problems experienced lower TC levels (-36.5 mg/dl, p=0.002) as compared to those who indicated “never.” Workers who believed their TC levels to be “no good” increased their TC levels (17.6 mg/dl, p=0.02) than those who indicated “good.” TC levels among female workers increased more so than among males throughout the course of the study (16.0 mg/dl, p=0.007). Eating breakfast <6 times per week (the lowest tertile of breakfast consumption) was associated with reduced TC levels as compared to eating breakfast every day (-16.9 mg/dl, p=0.005).

Discussion

This study found the sole characteristic associated with weight gain over the study duration is a belief they are overweight or obese. Characteristics associated with weight reductions included: consuming breakfast <6 times/week and baseline overweight and obesity. Characteristics associated with increases in TC levels over the study duration included: female gender, belief their TC levels were “not good,” and feeling depressed. Characteristics associated with TC reductions included: having family problems and consuming breakfast <6 times per week. To our surprise, fast food consumption was not associated with weight or TC level changes, except for breakfast consumption.

Surprisingly, leisure-time physical activity was not associated with TC changes. Workers reported baseline leisure-time physical activity that met exercise guidelines[35] (mean 282.6±314.3), but not at study completion (119.6±173.1).

A meta-analysis of 95 studies assessing exercise effects on serum lipid and lipoprotein levels found exercise lowered cholesterol levels by 7 to 13 mg/dl compared with controls, [36, 37] with larger reductions among those losing weight. However, questionnaires assessing physical activity levels are subject to recall errors and biases. We suspect that most workers over-reported their leisure-time physical activity levels.

We were also surprised that fat intake and fast food consumption were not significantly associated with TC or weight changes. Reductions in saturated fat, dietary cholesterol, and weight are considered to offer the most effective dietary strategies for reducing total cholesterol. [38, 39] However, controlled studies have reported only modest long-term reductions in TC. [37]

Short-term decreases in TC of 10% to 20% have resulted from a controlled low-fat diet. [37] This study's findings may be partially due to a single assessment of dietary intake at exit among the workers. We found significant associations between family problems and reductions in TC.

These findings are somewhat concurrent with other research studies. Symptoms of depression and anxiety have been associated with decreased levels of HDL cholesterol and increased abdominal obesity.[40] Researchers found that anxiety is a proxy risk factor for depression severity in aggravating dyslipidemia.[40]

Less than 10% of workers reported knowing their TC levels at study exit, although all had received results from this study many years previously.

Most workers (53.9%) who believed their TC was "not good" actually had normal TC levels (<200mg/dl). Yet, considering only 57% of workers with abnormal baseline TC levels recalled having been informed of their TC levels by a physician, suggests a need for more intensive interventions.

These results also showed no significant associations between health education and changes in TC and weight. It is widely believed that awareness and knowledge of factors associated with negative health outcomes is necessary before health promotion programs can be successfully implemented. [31, 41-44]

The prevalence of obesity in this working population (57.5%) was greater than the U.S. adult population (35.7%).[1] This is also greater than the reported obesity prevalence among the general population in Utah (22.5%)[45], and is twice as high as a recently reported prevalence for U.S. workers (27.7%).[46]

Given the impacts of BMI and TC on healthcare and occupational costs,[3-7] this research analyzed a target population that should be disposed to improvements in weight, TC and other weight-related comorbidities.

Strengths of this study include 1) anthropometric measures, 2) ability to collect data from the same population up to 9 years apart, 3) recruitment from a wide array of employment settings to improve generalizability of the results, and 4) computerized data collection methods of questionnaires.

Several factors limit these findings. Measurements were taken at two time points, which were mostly 5 to 9 years apart. We also cannot address temporal relationships for measures taken only at the exit, particularly knowledge of BMI, TC and dietary recall. Recall error and bias may particularly affect reporting of physical activity levels. Prior evidence suggests that overweight individuals tend to over-estimate their activity level.[47, 48]

Conclusion

Results suggest that most of the reported associations with increases in weight and TC levels among production workers are amenable to interventions and may be a target for workplace intervention programs. The need for these programs is also warranted by the high prevalence of obesity among workers. Given that the state of Utah ranks among the lowest obesity prevalence rates in the U.S., we were able to fill a gap in the literature but also identify a target population that is in need of weight loss interventions.

Table 5: Population demographic characteristics with self-reported health indicators at study completion (N=146)

	N	%
Age		
<35	29	19.9
≥35-≤55	86	58.9
>55	31	21.2
Gender*		
Female	74	50.7
Male	72	49.3
Race*		
White	98	67.1
African American or Black	2	1.4
Asian	2	1.4
Pacific Islander or Native Hawaiian	15	10.2
Hispanic or Latino	29	19.9
Marital Status*		
Never Married (Single)	23	15.8
Married	106	72.6
Divorced	13	8.9
Separated	4	2.7
Education Level*		
Some high school	7	4.8
High school graduated or GED	68	46.6
Some college	57	39.0
College graduate (Bachelor's degree or higher)	14	9.6
Measured BMI Status (kg/m^{2})		
Underweight (BMI < 18.5)	2	1.4
Normal (BMI 18.5–24.9)	19	13.0
Overweight (BMI 25–29.9)	41	28.1
Obese (BMI ≥ 30)	84	57.5
Do you know what your Body Mass Index is?		
Yes	7	4.8
No	139	95.2
Do you believe you are:		
Underweight	9	6.2
Normal Weight	31	21.2
Overweight	86	58.9
Obese	18	12.3
Unsure	2	1.4
Do you know what your current TOTAL Blood Cholesterol is?		
Yes	12	8.2

Table 5: continued

	N	%
No	134	91.8
Do you think your Total Cholesterol is:		
Good	67	45.9
Not good	26	17.8
Unsure	53	36.3
Do you currently take Cholesterol –Lowering Medication?		
Yes	29	19.9
No	117	80.1
Restaurant or Fast Food Consumption (per week)		
≤1	92	63.0
2	23	15.8
≥3	31	21.2
Breakfast Consumption (per week)		
<6	51	34.9
6	10	6.9
≥7	85	58.2
Fruit and Vegetables Combined (Servings/Day)		
<5	62	42.5
≥5	84	57.5
How Often do you have Family Problems that Irritate or Bother You		
Never	28	19.2
Sometimes	101	69.2
Often	14	9.6
Always	3	2.0
How Often do you feel Down, Blue or Depressed		
Never	54	37.0
Sometimes	77	52.7
Often	13	8.9
Always	2	1.4
How Often do you Feel Nervous		
Never	37	25.4
Sometimes	90	61.6
Often	18	12.3
Always	1	0.7
How satisfied are you with your job?		
Very satisfied	72	49.3
Somewhat satisfied	58	39.7
A little satisfied	13	8.9
Not at all satisfied	3	2.1

Table 5: continued

	Mean±SD
Age (Years)	49.6±10.6
BMI (kg/m^2)	31.6±7.4
Leisure-Time Physical Activity (min/week)*	282.6±314.3
Leisure-Time Physical Activity (min/week)	119.6±173.1

*Assessed at baseline

Table 6: Comparison of weight and total cholesterol at baseline and study completion (N=146)

	Mean ± SD		
	Baseline Measures	**Study Completion Measures**	**P-Value**
Weight (kg)	86.9±23.6	90.5±24.5	0.003
Total Cholesterol (mg/dl)	194.4±36.3	182.1±37.8	<0.0001
<200mg/dl N (%)	81 (55.5)	102 (69.9)	
≥200mg/dl N (%)	65 (44.5)	44 (30.1)	

Table 7: Multivariate analyses of associations with weight change (kg)* from baseline to study completion.

	Estimate	Standard Error	P-Value
Age (Years)	-0.1	0.1	0.6
Baseline BMI (kg/m2)			
Underweight	1.1	7.8	0.9
Normal Weight		Reference	
Overweight	-7.5	3.0	0.01
Obese	-11.2	3.1	0.0003
Baseline Leisure-Time Total Physical Activity (min/week)			
0-240		Reference	
240-480	3.9	2.9	0.2
>480	0.9	2.9	0.8
Gender			
Female	-1.4	2.3	0.5
Male		Reference	
Breakfast Consumed (Times/Week)			
<6	-4.4	2.3	0.05
6	-5.3	4.3	0.2
≥7		Reference	
Nutrition/Diet Education**			
Yes		Reference	
No	-0.3	2.9	0.9
Physical Fitness Education**			
Yes		Reference	
No	-0.5	2.5	0.8
Weight Management Education**			
Yes		Reference	
No	4.1	2.7	0.1
Do you know what your Body Mass Index (BMI) is?			
Yes		Reference	
No	5.7	4.7	0.2
Do you believe you are:			
Underweight	-2.6	9.0	0.7
Normal Weight		Reference	
Overweight	6.7	2.7	0.02
Obese	14.4	3.9	0.0004
Not sure or don’t know	-5.4	9.0	0.6

Table 7: continued

	Estimate	Standard Error	P-Value
Do you think your Total Cholesterol is:			
Good		Reference	
Not Good	-0.4	2.8	0.9
Unsure	1.2	2.4	0.6
Fast Food Consumed/Week* **			
≤1		Reference	
2	0.7	2.9	0.8
≥3	1.3	2.6	0.6
Cohort			
DUE		Reference	
LBP	-0.4	2.3	0.9

*Weight Changes=Weight Study Completion (kg) - Weight Baseline (kg)
**Throughout the duration of this study, have you received any education (your doctor, the internet, magazines etc) in:
***How many times do you eat restaurant or fast food in a typical week? (For example Chili's™, McDonald's™, Burger King™, or your local diner. Take home leftovers count twice)

Table 8: Multivariate analyses of associations with TC changes (mg/dl)* from baseline to study completion.

	Estimate	Standard Error	P-Value
Baseline Age (Years)	-0.7	0.3	0.04
Baseline BMI (kg/m2)			
Underweight	12.6	19.1	0.51
Normal Weight		Reference	
Overweight	-7.3	7.2	0.31
Obese	-8.3	6.9	0.23
Baseline Leisure-Time Total Physical Activity (min/week)			
0-240		Reference	
240-480	5.9	7.8	0.45
>480	9.7	7.5	0.20
Baseline Cholesterol (md/dl)			
<200		Reference	
≥200	-15.0	5.5	0.007
Gender			
Female	16.0	5.8	0.007
Male		Reference	
Nutrition/Diet Education* **			
Yes		Reference	
No	10.0	7.7	0.19
Physical Fitness Education* **			
Yes		Reference	
No	-3.5	6.6	0.60
Weight Management Education* **			
Yes		Reference	
No	-7.6	6.8	0.27
Do you think your Total Cholesterol is:			
Good		Reference	
Not Good	17.6	7.4	0.02
Unsure	-2.3	6.3	0.72
Do you know what your current TOTAL Blood Cholesterol is?			
Yes		Reference	
No	-3.1	10.3	0.76
Do you currently take Cholesterol –Lowering Medication?			
Yes		Reference	
No	29.0	6.8	<0.0001

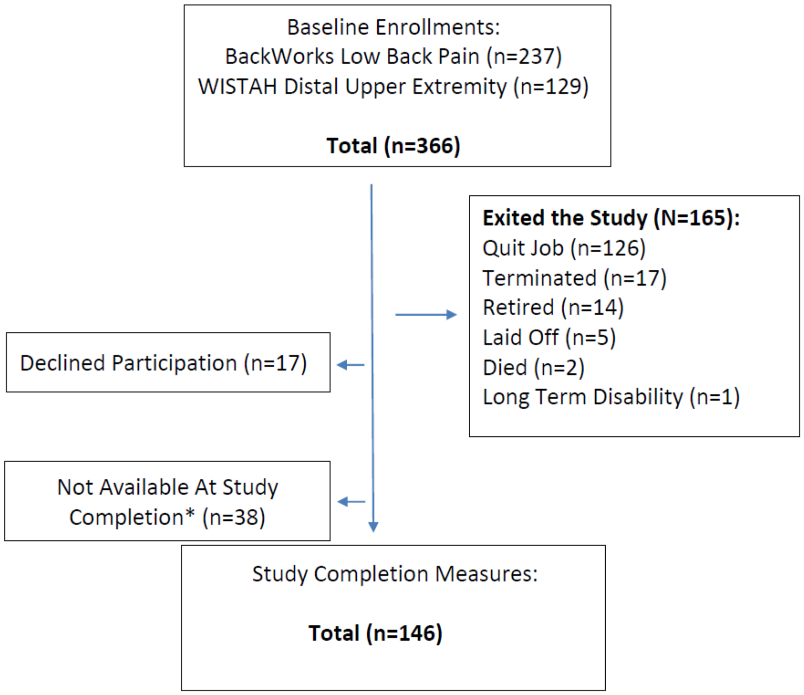
Table 8: continued

	Estimate	Standard Error	P-Value
Fast Food Consumed/Week**			
≤1		Reference	
2	7.9	7.6	0.3
≥3	3.8	6.7	0.6
Fruit and Vegetables Combined (Servings/Day)			
<5	-3.9	5.5	0.48
≥5		Reference	
Breakfast Consumed (Times/Week)			
<6	-16.9	5.9	0.005
6	-11.3	11.2	0.31
≥7		Reference	
Feeling Down, Blue or Depressed			
Never		Reference	
Sometimes	5.2	5.6	0.35
Often	14.7	11.0	0.18
Always	112.4	42.3	0.009
Family Problems that Irritate or Bother You			
Never		Reference	
Sometimes	-3.4	6.8	0.62
Often	-36.5	11.6	0.002
Always	-35.5	35.7	0.32
Cohort			
DUE		Reference	
LBP	4.6	6.3	0.46

*TC Changes=Study Completion TC - Baseline TC

**How many times do you eat restaurant or fast food in a typical week? (For example Chili's™, McDonald's™, Burger King™, or your local diner. Take home leftovers count twice)

***Throughout the duration of this study, have you received any education (your doctor, the internet, magazines etc) in:



*Participants were missed for the following reasons: vacation, sick, all-day meetings, worked graveyard shift

Figure 1: Flowchart of study participants from baseline enrollments to study completion measures.

References

1. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009-2010. *NCHS Data Brief* 2012:1-8.

2. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA* 2012;307:491-497.

3. Bertera RL. The effects of behavioral risks on absenteeism and health-care costs in the workplace. *J Occup Med* 1991;33:1119-1124.

4. Henke RM, Carls GS, Short ME, et al. The relationship between health risks and health and productivity costs among employees at Pepsi Bottling Group. *J Occup Environ Med* 2010;52:519-527.

5. Chronic Disease Prevention and Health Promotion: Obesity. Available at: http://www.cdc.gov/chronicdisease/resources/publications/aag/obesity.htm. Accessed: February 4, 2013.

6. Trust for America's Health and the Robert Wood Johnson Foundation. F as in Fat: How Obesity Threatens America's Future. [Serial online]. 2012;2013(September). Available from: http://healthyamericans.org/report/100/.

7. Irving DB, Cook JL, Young MA, Menz HB. Obesity and pronated foot type may increase the risk of chronic plantar heel pain: a matched case-control study. *BMC Musculoskeletal Disorders* 2007;8:41.

8. Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. *Osteoarthritis and Cartilage / OARS, Osteoarthritis Research Society* 2010;18:24-33.

9. Wendelboe AM, Hegmann KT, Biggs JJ, et al. Relationships between body mass indices and surgical replacements of knee and hip joints. *Am J Prev Med* 2003;25:290-295.

10. Kohatsu ND, Schurman DJ. Risk factors for the development of osteoarthrosis of the knee. *Clinical Orthopaedics and Related Research* 1990:242-246.

11. Bagge E, Bjelle A, Eden S, Svanborg A. Factors associated with radiographic osteoarthritis: results from the population study 70-year-old people in Goteborg. *The Journal of Rheumatology* 1991;18:1218-1222.

12. Felson DT. The epidemiology of knee osteoarthritis: results from the Framingham Osteoarthritis Study. *Seminars in Arthritis and Rheumatism* 1990;20:42-50.

13. Heuch I, Hagen K, Zwart JA. Body mass index as a risk factor for developing chronic low back pain: a follow-up in the Nord-Trondelag Health Study. *Spine* 2013;38:133-139.

14. Leino-Arjas P, Solovieva S, Kirjonen J, Reunanen A, Riihimaki H. Cardiovascular risk factors and low-back pain in a long-term follow-up of industrial employees. *Scandinavian Journal of Work, Environment & Health* 2006;32:12-19.

15. Miranda H, Viikari-Juntura E, Punnett L, Riihimaki H. Occupational loading, health behavior and sleep disturbance as predictors of low-back pain. *Scandinavian Journal of Work, Environment & Health* 2008;34:411-419.

16. Tubach F, Leclerc A, Landre MF, Pietri-Taleb F. Risk factors for sick leave due to low back pain: a prospective study. *J Occup Environ Med* 2002;44:451-458.

17. Van Nieuwenhuyse A, Crombez G, Burdorf A, et al. Physical characteristics of the back are not predictive of low back pain in healthy workers: a prospective study. *BMC Musculoskeletal Disorders* 2009;10:2.

18. Morken T, Moen B, Riise T, et al. Prevalence of musculoskeletal symptoms among aluminium workers. *Occup Med (Lond)* 2000;50:414-421.

19. Silverstein BA, Bao SS, Fan ZJ, et al. Rotator cuff syndrome: personal, work-related psychosocial and physical load factors. *J Occup Environ Med* 2008;50:1062-1076.

20. Miranda H, Viikari-Juntura E, Martikainen R, Takala EP, Riihimaki H. A prospective study of work related factors and physical exercise as predictors of shoulder pain. *Occupational and Environmental Medicine* 2001;58:528-534.

21. Luime JJ, Verhagen AP, Miedema HS, et al. Does this patient have an instability of the shoulder or a labrum lesion? *JAMA* 2004;292:1989-1999.

22. Wendelboe AM, Hegmann KT, Gren LH, Alder SC, White GL, Jr., Lyon JL. Associations between body-mass index and surgery for rotator cuff tendinitis. *The Journal of Bone and Joint Surgery, American Volume* 2004;86-A:743-747.

23. Roquelaure Y, Ha C, Rouillon C, et al. Risk factors for upper-extremity musculoskeletal disorders in the working population. *Arthritis and Rheumatism* 2009;61:1425-1434.

24. Nathan PA, Keniston RC, Myers LD, Meadows KD. Obesity as a risk factor for slowing of sensory conduction of the median nerve in industry. A cross-sectional and longitudinal study involving 429 workers. *J Occup Med* 1992;34:379-383.

25. Andersen RE, Crespo CJ, Bartlett SJ, Bathon JM, Fontaine KR. Relationship between body weight gain and significant knee, hip, and back pain in older Americans. *Obesity Research* 2003;11:1159-1162.

26. Janssen I, Bacon E, Pickett W. Obesity and its relationship with occupational injury in the canadian workforce. *Journal of Obesity* 2011;2011:531403.

27. Pollack KM, Sorock GS, Slade MD, et al. Association between body mass index and acute traumatic workplace injury in hourly manufacturing employees. *American Journal of Epidemiology* 2007;166:204-211.

28. Garg A, Kapellusch J, Hegmann K, et al. The Strain Index (SI) and Threshold Limit Value (TLV) for Hand Activity Level (HAL): risk of carpal tunnel syndrome (CTS) in a prospective cohort. *Ergonomics* 2012;55:396-414.

29. Marcus BH, Rakowski W, Rossi JS. Assessing motivational readiness and decision making for exercise. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association* 1992;11:257-261.

30. Marcus BH, Simkin LR. The stages of exercise behavior. *The Journal of Sports Medicine and Physical Fitness* 1993;33:83-88.

31. Alm-Roijer C, Stagmo M, Uden G, Erhardt L. Better knowledge improves adherence to lifestyle changes and medication in patients with coronary heart disease. *Eur J Cardiovasc Nurs* 2004;3:321-330.

32. Garg A, Hegmann KT, Moore JS, et al. Study protocol title: a prospective cohort study of low back pain. *BMC Musculoskeletal Disorders* 2013;14:84.

33. Garg A, Hegmann KT, Wertsch JJ, et al. The WISTAH hand study: a prospective cohort study of distal upper extremity musculoskeletal disorders. *BMC Musculoskeletal Disorders* 2012;13:90.

34. Greenwood JL, Murtaugh MA, Omura EM, Alder SC, Stanford JB. Creating a clinical screening questionnaire for eating behaviors associated with overweight and obesity. *J Am Board Fam Med* 2008;21:539-548.

35. 2008 Physical Activity Guidelines for Americans. Available at: http://www.health.gov/paguidelines/pdf/paguide.pdf. Accessed: March 25, 2014.

36. Tran ZV, Weltman A. Differential effects of exercise on serum lipid and lipoprotein levels seen with changes in body weight. A meta-analysis. *JAMA: The Journal of the American Medical Association* 1985;254:919-924.

37. Screening for Lipid Disorders. Available at: http://www.ahrq.gov/downloads/pub/prevent/pdfser/lipidser.pdf. Accessed: August 20, 2012.

38. Lichtenstein AH, Van Horn L. Very low fat diets. *Circulation* 1998;98:935-939.

39. Fletcher B, Berra K, Ades P, et al. AHA Scientific Statement. Managing abnormal blood lipids: a collaborative approach. *Circulation* 2005;112:3184-3209.

40. van Reedt Dortland AK, Giltay EJ, van Veen T, Zitman FG, Penninx BW. Longitudinal relationship of depressive and anxiety symptoms with dyslipidemia and abdominal obesity. *Psychosomatic Medicine* 2013;75:83-89.

41. Han W, Piterman L, Morris N, McCall L. The knowledge of and attitudes towards serum cholesterol in the Chinese patients in a family practice in Hong Kong. *Hong Kong Practitioner* 1998;20:307-318.

42. Tanaka T, Okamura T, Yamagata Z, et al. Awareness and treatment of hypertension and hypercholesterolemia in Japanese workers: the High-risk and Population Strategy for Occupational Health Promotion (HIPOP-OHP) study. *Hypertens Res* 2007;30:921-928.

43. Celentano A, Panico S, Palmieri V, et al. Citizens and family doctors facing awareness and management of traditional cardiovascular risk factors: results from the Global Cardiovascular Risk Reduction Project (Help Your Heart Stay Young Study). *Nutr Metab Cardiovasc Dis* 2003;13:211-217.

44. Celentano A, Palmieri V, Arezzi E, et al. Cardiovascular secondary prevention: patients' knowledge of cardiovascular risk factors and their attitude to reduce the risk burden, and the practice of family doctors. The "Help Your Heart Stay Young" study. *Ital Heart J* 2004;5:767-773.

45. Overweight and Obesity: Utah State Nutrition, Physical Activity, and Obesity Profile. Available at: http://www.cdc.gov/obesity/stateprograms/fundedstates/pdf/utah-state-profile.pdf. Accessed: April 20, 2014.

46. Luckhaupt SE, Cohen MA, Li J, Calvert GM. Prevalence of obesity among U.S. Workers and associations with occupational factors. *Am J Prev Med* 2014;46:237-248.

47. Jakicic JM, Polley BA, Wing RR. Accuracy of self-reported exercise and the relationship with weight loss in overweight women. *Medicine and Science in Sports and Exercise* 1998;30:634-638.

48. Lichtman SW, Pisarska K, Berman ER, et al. Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. *The New England Journal of Medicine* 1992;327:1893-1898.

CHAPTER 4

STAGES OF WEIGHT CHANGES AMONG
AN OCCUPATIONAL
COHORT

Abstract

Purpose

The purpose was to assess the readiness to change dietary intake and body weight among production workers. We also ascertained differences between self-perceived and measured body mass index (BMI).

Design/Methodology/Approach

This cross-sectional study was nested within two prospective cohort studies. We used a laptop administered questionnaire to query physical activity, psychosocial factors, fruit and vegetable intake and knowledge of body mass index (BMI) and total cholesterol (TC) levels. The questionnaire also incorporated questions about readiness to change based on the transtheoretical model (TTM).

Findings

A total of 227 production workers participated in this study. Sixty three (27.8%) workers were overweight (BMI 25–29.9 kg/m^2), and 114 (50.2%) were obese (BMI $\geq$ 30 kg/m^2). Obese workers were in the following stages of weight change: precontemplation 4 (3.5%), contemplation 51(44.8%), preparation 15 (13.2%), action 24 (21.1%), and 20 (17.5%) maintenance. The stages of change were similar for reducing fat or increasing fruit intake. Ten percent of overweight workers (n=22) erroneously reported their BMI to be normal. Moreover, a plurality of obese workers (n=80, 36.4%) thought of themselves as being merely overweight.

Originality/Value

About half of overweight/obese workers were in the precontemplation or contemplation stages for healthy dietary changes or weight loss. We found a substantial disconnect between workers' measured BMI and self-perceived BMI. Recognizing the stages of change with regard to weight and the self-perception of weight status may help health professionals in the workplace to tailor workplace health promotion programs.

Introduction

Obesity-related medical costs for U.S. adults have been estimated by the CDC at $147 billion in 2008, with each obese adult having medical costs averaging $1,429 higher than for a normal weight adult.[1] Beyond medical costs, being overweight, defined as BMI 25-29.9kg/m^2 has been found to predict sick leave episodes lasting longer than 7 days. [2, 3] An association between BMI and long-term absenteeism (more than 22 days over a 4-

year period) has also been reported.[4] Additionally, obesity has been associated with an increased risk of occupational injuries and illnesses. [5-8, 9-12]

Obesity is associated with health related job limitations, especially for jobs with high physical demands or those requiring short times to complete tasks.[13] Obese workers have difficulty moving to perform job functions due to body size and associated physical limitations.[13] Obesity has also been widely associated with musculoskeletal or joint-related pain in the feet[14], knees[15-19], back[20-24], shoulders[12, 25-29], and hands. [30, 31] Additionally, obesity has been associated with an increased risk of occupational injuries. [5, 6] Reported injuries attributed to obesity include sprains, strains, injuries to the lower limb or torso, and injuries due to falls or overexertion. [5]

The U.S. civilian workforce employed approximately 140 million people in 2009. [32] Workers spend a quarter of their lifetime, and up to half of their waking lives at work or commuting.[33] It is estimated that 65% of the U.S. adult population could potentially be reached by workplace health intervention programs if they were universally available.[33]

Distorted perceptions of adults' weight status have been widely reported.[34-38] For example, one-quarter of overweight and obese adults in the National Health and Nutrition Examination Survey (NHANES) misperceived their weight status.[36] These individuals were also reportedly less likely to either have wanted to, or attempted to lose weight. [36] Misperceptions among those overweight or obese may be a considerable barrier for weight loss interventions and behavior change.

To the best of our knowledge, there are no data available regarding perceptions of weight status and intentions for diet change among production workers. We therefore studied the readiness to change dietary intake and weight, assessed by questions based on the Transtheoretical Model (TTM) of behavior change. We also ascertained differences between self-perceived and measured BMI.

Methods

This cross-sectional study was nested within two prospective cohorts (the WISTAH Distal Upper Extremity (DUE) cohort and the BackWorks Low Back Pain (LBP) cohort). [39, 40] Both studies were approved by the University of Utah's Institutional Review Board (#s 00010930 and 00011889). Baseline data for these cohorts were collected during worksite enrollments conducted between 2002 and 2007. Additional data for this study were collected during study completion visits in the Spring of 2012 and analyzed in 2013. The parent cohort studies have detailed methods papers published[39, 40], thus a brief summary of the methods follows.

Subjects

Subjects were at least 18 years of age at enrollment and employed at one of eight participating companies in Utah. Subjects were excluded if they could not give informed consent, did not speak either English or Spanish and were planning to retire within 4 years of study enrollment. To improve generalizability of the results, subjects were recruited from eight varying employment settings i.e., airbag manufacturing, office workers, sewing facility, red meat processing, printing operations, cabinet manufacturing, medical technology production facility, and aluminum extrusion facility.[39, 40]

Baseline Measures

At baseline enrollments, workers completed a laptop administered questionnaire under the supervision of a research assistant. Baseline data utilized included the following demographics: age, gender, education level, and race. Education levels were grouped into two categories for the analyses: 1) 8th grade or less, some high school, high school graduate or GED; and 2) some college, college graduate (Bachelor's degree or higher).

Height and weight were measured in stocking feet. If weight exceeded 200kg, two scales were used simultaneously and the sum was recorded. A BMI < 18.5 kg/m^2 was considered underweight, between 18.5 and 24.9 kg/m^2 was considered normal, 25-29.9 kg/m^2 was considered overweight and >30 kg/m^2 obese.[41] Height was assumed to have not changed appreciably during the study.

Measures at End of Study

At study completion, subjects completed another laptop administered questionnaire and their weight was re-measured. Survey items quantified physical activity outside work, psychosocial factors (e.g., depression, job satisfaction, and family problems), knowledge of BMI, knowledge of TC levels, fruit and vegetable intake, and questions based on the TTM[42-44], assessing readiness to change fruit and fat intake as well as readiness to change weight.

Leisure-time physical activity questions addressed 21 specific activities (e.g., baseball, basketball); additionally, other nonspecified activities could be added.[39, 40] Each of those activities was further queried for the number of months per year, the average number of times per week, and the average number of minutes each activity was performed. A composite of all these activities was calculated and the total reported leisure-time physical activity in minutes per week was assessed.

Dietary intake questions were included that have been previously developed and were slightly modified for this population. [45] Fruit and vegetable intake was assessed by asking "How many times do you typically eat a serving of fruit in one day?" and "How many times do you typically eat a serving of vegetables in one day?"

Questions also aimed to determine subject's current stages of change based on the TTM. TTM was developed in 1981 by Prochaska et al. [42-44] and has been widely utilized in the health promotion and education field.[42, 46-52] It incorporates concepts from previously developed models such as the Health Belief Model.[52] Questions for each health indicator (diet and weight) were adapted from previous studies.[46-52] Readiness to change weight was adapted [48] and modified for this study by asking subjects to select 1 out of 7 statements, each representing a stage of change to the following question: "Which statement best describes how you feel about your weight?" Possible responses included: "My weight is about right and I am not planning on trying to change it." (Precontemplation), "I want to lose weight, but I don't know where to start." (Contemplation), "I have decided to lose weight and I have a plan to start in the next 6 months." (Contemplation), "I am trying to gain weight." (Contemplation), "I plan on starting to make changes (diet, exercise, etc.) within the next month." (Preparation), "I have recently made changes to lose weight (within 6 months)." (Action), and "I have been making changes to lose weight for longer than 6 months." (Maintenance). Similar questions were used to determine stages of change regarding fat and fruit intake.

Subjects were asked whether they could recall their current BMI (Yes/No). Questions on how subjects perceive their weight and TC were also included. Subjects were asked “Do you think your Total Cholesterol is: Good/ Not Good/Unsure?” and “Do you believe you are: Underweight/Normal Weight/Overweight/Obese/Unsure?” Intake of cholesterol-lowering medication was also assessed.

Having received any education (e.g., doctor, the internet, magazines) in weight management, diet/nutrition or physical fitness throughout the study duration was also assessed. Weight was measured in stocking feet at study completion.

Data Analyses

All analyses were performed using SAS 9.3 (SAS Institute, Cary, North Carolina). Outliers and missing study data were verified by pulling individual subject’s charts. Imputation using the study mean was used when missing data could not be verified: total cholesterol and weight were each imputed for two subjects.

Correlation statistics were conducted for characteristics which were hypothesized to be associated.

Population demographics at study completion were analyzed using frequencies, means and standard deviations. Stages of change were calculated as frequencies for the entire population, for those who are overweight or obese (BMI ≥ 25) and for those who believe they are overweight or obese.

Differences in distributions across categorical variables were assessed with a chi-square test. Fisher’s exact test was used for variables that had a frequency of five or less in a cell. Statistical significance was assessed by using α level of 0.05.

Results

A total of 227 subjects participated in study completion visits. The majority of subjects were between 30-50 years old (45.8%), female (56.0%), White (55.5%) and were high school graduates or had their GED (45.4%). See Table 9 for demographic data. Subjects had a mean BMI of 30.8±7.4 kg/m^2 with 50.2% being obese and 27.8% overweight. The vast majority indicated not knowing their BMI (90.8%) or TC levels (89.9%). Most (80.2%) reported being physically active for less than 240 minutes per week. Most (63.0%) reported consuming at least 5 servings of fruits and vegetables combined.

We assessed the association of the following characteristics: 1) baseline weight and stages of weight change at study completion, 2) baseline BMI and stages of weight change at study completion, 3) weight change from baseline to study completion and stages of weight change at study completion. However, no correlation between any of these characteristics was found.

Stages of change for weight, fat and fruit intake are summarized in Table 10, stratified by baseline actual BMI or self-perceived weight status. A plurality (n=51, 44.8%) of obese workers either wanted to lose weight but did not know where to start or had decided to lose weight and planned to start in the next 6 months.

In addition, 23.8% (n=15) of overweight workers thought their weight was about right (healthy) and they did not want to change it.

Similarly, most workers who believed to be overweight (n=50, 40.7%) or obese (n=10, 41.7%) were contemplating weight loss. Only 33.3% (n=8) of workers who believed they were obese were in the maintenance stage of weight reduction. The plurality of obese workers were in the precontemplation phase regarding their fat intake (n=36, 31.6%). Most overweight workers were in the contemplation or precontemplation (n=26, 41.2%) stage for decreasing fat intake. In addition, most believing themselves to be obese were in the precontemplation stage regarding increasing their fruit intake (n=10, 41.7%). Those workers had no plans of eating more fruit. Only 21.1% (n=24) of obese workers reported having tried to eat more fruit recently.

Stratified results of stages of weight change for workers with a BMI $\geq$ 25 kg/m^2 are presented in Table 11. Regarding obese workers, 44.7% (n=51) indicated being in the contemplation phase for weight change.

Only 21.1% (n=24) of obese workers indicated having recently made changes to lose weight. Among overweight workers, 49.2% (n=31) either thought their weight was about right and either did not want to change it or wanted to lose weight but did not know where to start. Similarly, 40.5% (n=47) of those who self-reported to be overweight were contemplating weight change.

The majority of workers with a BMI$\geq$25 kg/m^2 performed less than 240 minutes of leisure-time physical activity per week (n=140, 79.1%). Moreover, most of them were contemplating weight loss (n=61, 43.6%). Only 6% (n=10) of workers with a BMI$\geq$25 kg/m^2 reported participating in more than 480 minutes per week of leisure physical activity.

Figure 2 shows the distribution of measured BMI and self-perceived BMI status. Workers who indicated being “Unsure” about their BMI (n=7) were excluded from this graph. Ten percent of the workers (n=22, 10.0%) who were overweight believed their BMI was normal. A plurality of workers (n=80, 36.4%) who were obese thought they were merely overweight and rejected the option of “obese” in the questionnaire.

Some of those who were obese (n=8, 3.6%) thought they were of normal weight, and rejected “overweight” and “obese” categories for their weight. Of those with a normal BMI, 2.7% (n=6) believed they were overweight, while 4.4% (n=10) even classified themselves as being underweight.

Discussion

The combined prevalence of overweight and obesity of 77.9% in this working population is astonishing. The prevalence of obesity (50.2%) is greater than for the U.S. adult population (35.7%)[53] and is twice as high as a recently reported prevalence for U.S. workers (27.7%).[7] Considering an even lower prevalence of 22.5% for obesity in the state of Utah,[54] these production workers represent an important target population for weight loss interventions.

There appears to be a disconnect between workers’ measured and self-perceived BMIs, especially among the obese. Ten percent of overweight workers (n=22, 10.0%) believed their BMI to be normal, while a plurality of obese workers (n=80, 36.4%) thought they were overweight. Disconnects between actual and perceived body weights have been previously shown. [36, 55] NHANES reported that 23% of their large population misperceived their weight, [36] compared with 58.1% of this study’s workers who misperceived weight. Self-perceptions of being overweight are reportedly more common in women,[55] and also vary by sex, race, and socioeconomic status.[55] Correction of these misconceptions may be an important consideration for the design of effective weight loss interventions.[36] While this might represent nominal semantics, further investigation is warranted to determine the meaning and influence of these disconnects on health. It may not be as clinically meaningful if our workers can distinguish between being overweight or obese as opposed to simply being able to being aware of not being at a normal weight.

A plurality of overweight (n=31, 49.5%) and obese (n=55, 48.3%) production workers were in the precontemplation and contemplation stage of weight change. Workplace promotion programs in our participating facilities, which aim to help workers move along advanced stages of change, may not be useful for workers in the precontemplation or contemplation stages of change. The majority of this working population may need support taking the first step for changing their weight. Future research may analyze workplace promotion programs to determine which stages of change are being targeted.

Pluralities of obese workers also fell into the precontemplation phase regarding their fat (n=36, 31.6%) and fruit (n=32, 28.1%) intake. Those workers did not have any plans of eating more or less fruit (fat) or did not know what the fat content of their diet is. Only 21.1% (n=24) of obese workers had taken action and indicated having tried to eat more fruit recently. Similarly, only 18.4% (n=21) of them had taken action to decrease their fat intake recently.

A study conducted to assess the stage of readiness to control weight and adopt weight control behaviors in primary care found that 72% of those overweight or obese were at advanced stages (preparation, action or maintenance) for weight loss.[56] In contrast, the majority of obese and overweight workers in this study was contemplating weight loss but had not taken any action. Therefore, it may be appropriate to aim workplace promotion programs to provide specific strategies to move workers into higher stages of behavior change. Workers who are ambivalent or contemplating behavior change may not benefit from workplace promotion programs aimed at advanced stages of change (e.g., action stage).

Strengths of this study include 1) anthropometric measures of body weight and body height, 2) recruitment from a variety of employment settings to improve generalizability of the results, and 3) computerized questionnaires.

Several factors limit these findings including the cross-sectional design for the stages of change data. Recall bias inherently limits self-reported studies. Stages of change may have been overestimated. Self-report also likely affected reporting of physical activity. The majority of subjects who reported more than 480 minutes of physical activity were overweight or obese (n=10, 83.3%). Evidence supports the belief that overweight individuals tend to over-estimate or over-report the amount of activity they perform.[57, 58]

Given the well documented impact of obesity on occupational illnesses, injuries, and overall increasing productivity costs, this research identified a target population for interventions to improve weight and weight related comorbidities. The Bureau of Labor Statistics estimates U.S. civilian employment of approximately 140 million people in 2009. [59] It is estimated that 65% of the adult population of the U.S. can be reached through worksites.[60] The workplace, therefore, may be an optimal location for workplace prevention programs in production facilities, targeted at weight loss interventions.

Conclusion

This population was 50.2% obese and 27.8% overweight. Despite these problems, a plurality of overweight or obese production workers were merely in the precontemplation or contemplation stages for weight loss. Of those who were obese, 36.4% thought of themselves as merely overweight. Potential impacts include that worksite health promotion programs in these occupational settings may be more effective by particularly identifying and targeting those in the precontemplation and contemplation stages.

Table 9: Population demographics and survey response frequencies at study completion (n=227)

	N (%)
Age (Years)	
≤30	34 (15.0)
>30- ≤50	104 (45.8)
>50	89 (39.2)
Gender*	
Female	127 (56.0)
Male	100 (44.1)
Race*	
White	126 (55.5)
African American or Black	2 (0.9)
Asian	25 (11.0)
Pacific Islander or Native Hawaiian	25 (11.0)
Hispanic or Latino	49 (21.6)
Education Level*	
8th grade or less	1 (0.4)
Some high school	18 (7.9)
High school graduated or GED	103 (45.4)
Some college	82 (36.1)
College graduate (Bachelor's degree or higher)	23 (10.2)
BMI Category (kg/m^2)	
Underweight (BMI < 18.5)	4 (1.8)
Normal (BMI 18.5–24.9)	46 (20.2)
Overweight (BMI 25–29.9)	63 (27.8)
Obese (BMI ≥ 30)	114 (50.2)
Mean Total Physical Activity Minutes per Week summed	
0 to 240	182 (80.2)
240 to 480	33 (14.5)
More than 480	12 (5.3)
Do you know what your Body Mass Index is?	
Yes	21 (9.2)
No	206 (90.8)
Do you believe you are:	
Underweight	14 (6.1)
Normal Weight	59 (26.0)
Overweight	123 (54.2)
Obese	24 (10.6)

Table 9: continued

	N (%)
Unsure	7 (3.1)
Do you know what your current TOTAL Blood Cholesterol is?	
Yes	23 (10.1)
No	204 (89.9)
Do you think your Total Cholesterol is:	
Good	106 (46.7)
Not good	37 (16.3)
Unsure	84 (37.0)
Fruit and Vegetables Combined (Servings/Day)	
<5	84 (37.0)
≥5	143 (63.0)
	Mean ± SD
Age (Years)	50.2±10.3
BMI (kg/m^2)	30.8±7.4
Total Physical Activity (minutes per week)	130.3±168.9
Total Cholesterol (mg/dL)	182.7±37.7

* These data were collected at baseline enrollments

Table 10: Stages of change N (%) among production workers (n=227) for weight reduction, fat intake and fruit intake at study completion, in relation to BMI or self-perceived weight status.

	Precontemplation	**Contemplation**	**Preparation**	**Action**	**Maintenance**	**Total**
			Weight Reduction			
Measured BMI<25	26 (52.0)	14 (28.0)	6 (12.0)	1 (2.0)	3 (6.0)	50
Measured BMI 25–29.9	15 (23.8)	16 (25.4)	10 (15.9)	10 (15.9)	12 (19.1)	63
Measured BMI≥30	4 (3.5)	51 (44.8)	15 (13.2)	24 (21.1)	20 (17.5)	114
Self-Perceived Normal Weight*	42 (52.5)	21 (26.3)	8 (10.0)	2 (2.5)	7 (8.7)	80
Self-Perceived Overweight*	3 (2.4)	50 (40.7)	19 (15.5)	31 (25.2)	20 (16.3)	123
Self-Perceived Obese*	0 (0)	10 (41.7)	4 (16.7)	2 (8.3)	8 (33.3)	24
			Decreasing Fat Intake			
Measured BMI<25	24 (48.0)	9 (18.0)	5 (10.0)	5 (10.0)	7 (14.0)	50
Measured BMI 25–29.9	13 (20.6)	13 (20.6)	9 (14.3)	13 (20.6)	15 (23.8)	63
Measured BMI≥30	36 (31.6)	27 (23.7)	15 (13.2)	21 (18.4)	15 (13.2)	114
Self-Perceived Normal Weight*	35 (43.8)	15 (18.8)	9 (11.3)	12 (15.0)	9 (11.3)	80
Self-Perceived Overweight*	31 (25.2)	28 (22.8)	17 (13.8)	23 (18.7)	24 (19.5)	123
Self-Perceived Obese*	7 (29.2)	6 (25.0)	3 (12.5)	4 (16.7)	4 (16.7)	24
			Increasing Fruit Intake			
Measured BMI<25	20 (40.0)	13 (26.0)	5 (10.0)	5 (10.0)	7 (14.0)	50
Measured BMI 25–29.9	19 (30.2)	8 (12.7)	8 (12.7)	23 (36.5)	5 (7.9)	63
Measured BMI≥30	32 (28.1)	22 (19.3)	16 (14.0)	24 (21.1)	20 (17.5)	114
Self-Perceived Normal Weight*	31 (38.8)	16 (20.0)	12 (15.0)	12 (15.0)	9 (11.3)	80
Self-Perceived Overweight*	30 (24.4)	23 (18.7)	16 (13.0)	34 (27.6)	20 (16.3)	123
Self-Perceived Obese*	10 (41.7)	4 (16.7)	1 (4.2)	6 (25.0)	3 (12.5)	24

*Assessed by asking: Do you believe you are: Underweight/Normal Weight/Overweight/Obese/Unsure.

Table 11: Stages of change for weight reduction among production workers with a BMI≥25 kg/m^2 at study completion (n=177). N (%)

	Precontemplation	Contemplation	Preparation	Action	Maintenance	Total	P-Value
Age							
≤30	3 (12.5)	9 (37.5)	1 (4.1)	7 (29.2)	4 (16.7)	24	<0.0001
>30- ≤50	10 (11.4)	39 (44.3)	10 (11.3)	14 (15.9)	15 (17.1)	88	
>50	6 (9.2)	19 (29.2)	14 (21.6)	13 (20)	13 (20.0)	65	
Gender*							
Female	8 (8.1)	37 (37.4)	18 (18.2)	15 (15.1)	21 (21.2)	99	0.1
Male	11 (14.1)	30 (38.5)	7 (9.0)	19 (24.3)	11 (14.1)	78	
Race*							
White	11 (10.5)	35 (33.3)	11 (10.5)	25 (23.8)	23 (21.9)	105	0.04
African American or Black	0 (0)	1 (50.0)	0 (0)	0 (0)	1 (50.0)	2	
Asian	3 (42.9)	2 (28.5)	0 (0)	1 (14.3)	1 (14.3)	7	
Pacific Islander or Native Hawaiian	2 (8.3)	8 (33.3)	9 (37.5)	2 (8.4)	3 (12.5)	24	
Hispanic or Latino	3 (7.7)	21 (53.8)	5 (12.8)	6 (15.4)	4 (10.3)	39	
Education Level[1]*							
High school graduated or GED	15 (23.8)	16 (25.4)	10 (15.9)	10 (15.9)	12 (19.0)	63	0.0007
Any College	4 (3.5)	51 (44.7)	15 (13.2)	24 (21.1)	20 (17.5)	114	

Table 11: continued

	Precontemplation	Contemplation	Preparation	Action	Maintenance	Total	P-Value
Mean Total Physical Activity Minutes per Week summed							
0 to 240	17 (12.1)	61 (43.6)	18 (12.9)	24 (17.1)	20 (14.3)	140	<0.0001
240 to 480	2 (7.4)	4 (14.8)	3 (11.1)	10 (37.1)	8 (29.6)	27	
More than 480	0 (0)	2 (20.0)	4 (40.0)	0 (0)	4 (40.0)	10	
BMI Category							
Overweight (BMI 25–29.9)	15 (23.8)	16 (25.4)	10 (15.9)	10 (15.9)	12 (19.1)	63	<0.0001
Obese (BMI ≥ 30)	4 (3.5)	51 (44.7)	15 (13.2)	24 (21.1)	20 (17.5)	114	
Do you know what your Body Mass Index (BMI) is?							
Yes	0 (0)	4 (36.3)	2 (18.2)	2 (18.2)	3 (27.3)	11	0.007
No	19 (11.4)	63 (37.9)	23 (13.9)	32 (19.3)	29 (17.5)	166	
Do you believe you are:							
Underweight	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)	1	<0.0001
Normal Weight	15 (50.0)	6 (20.0)	3 (10.0)	1 (3.3)	5 (16.7)	30	
Overweight	2 (1.7)	47 (40.5)	18 (15.5)	30 (25.9)	19 (16.4)	116	
Obese	0 (0)	10 (41.7)	4 (16.7)	2 (8.3)	8 (33.3)	24	
Unsure	2 (33.3)	3 (50.0)	0 (0)	1 (16.7)	0 (0)	6	

* These data were collected at baseline enrollments

[1] Education levels were grouped into two categories for the analyses: 1=8th grade or less, some high school, high school graduate or GED; 2=some college, college graduate (Bachelor's degree or higher).

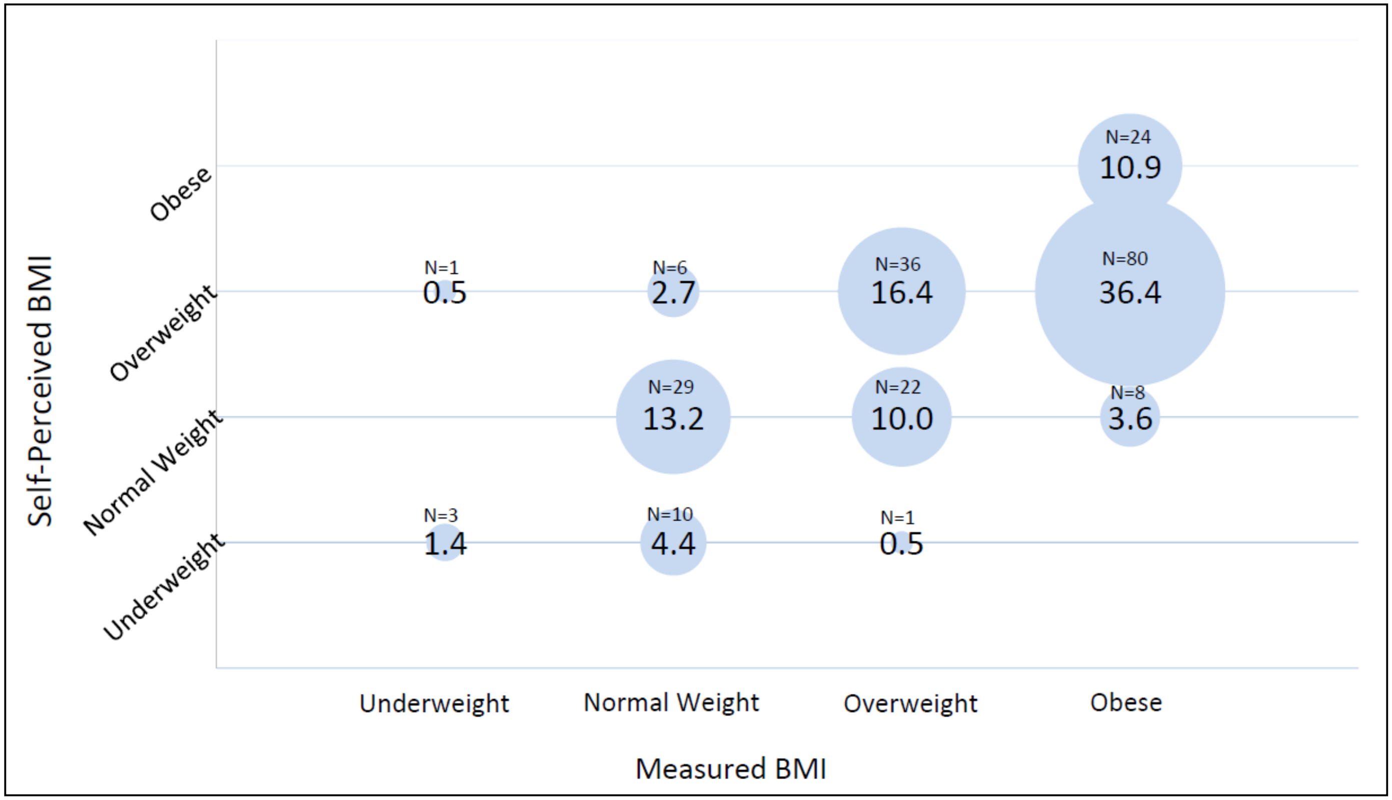


Figure 2: Agreement/disagreement (%) of measured BMI status and self-perceived BMI status among production workers (n=220)

.

References

1. Chronic Disease Prevention and Health Promotion: Obesity. Available at: http://www.cdc.gov/chronicdisease/resources/publications/aag/obesity.htm. Accessed: February 4, 2013.

2. van Duijvenbode DC, Hoozemans MJ, van Poppel MN, Proper KI. The relationship between overweight and obesity, and sick leave: a systematic review. *Int J Obes (Lond)* 2009;33:807-816.

3. Schmier JK, Jones ML, Halpern MT. Cost of obesity in the workplace. *Scandinavian Journal of Work, Environment & Health* 2006;32:5-11.

4. Jans MP, van den Heuvel SG, Hildebrandt VH, Bongers PM. Overweight and obesity as predictors of absenteeism in the working population of the Netherlands. *J Occup Environ Med* 2007;49:975-980.

5. Janssen I, Bacon E, Pickett W. Obesity and its relationship with occupational injury in the canadian workforce. *Journal of Obesity* 2011;2011:531403.

6. Pollack KM, Sorock GS, Slade MD, et al. Association between body mass index and acute traumatic workplace injury in hourly manufacturing employees. *American Journal of Epidemiology* 2007;166:204-211.

7. Luckhaupt SE, Cohen MA, Li J, Calvert GM. Prevalence of obesity among U.S. workers and associations with occupational factors. *Am J Prev Med* 2014;46:237-248.

8. Harris-Adamson C, Eisen EA, Dale AM, et al. Personal and workplace psychosocial risk factors for carpal tunnel syndrome: a pooled study cohort. *Occupational and Environmental Medicine* 2013;70:529-537.

9. Dale AM, Harris-Adamson C, Rempel D, et al. Prevalence and incidence of carpal tunnel syndrome in US working populations: pooled analysis of six prospective studies. *Scandinavian Journal of Work, Environment & Health* 2013;39:495-505.

10. Fransen M, Woodward M, Norton R, Coggan C, Dawe M, Sheridan N. Risk factors associated with the transition from acute to chronic occupational back pain. *Spine* 2002;27:92-98.

11. Garg A, Kapellusch J, Hegmann K, et al. The Strain Index (SI) and Threshold Limit Value (TLV) for Hand Activity Level (HAL): risk of carpal tunnel syndrome (CTS) in a prospective cohort. *Ergonomics* 2012;55:396-414.

12. Wendelboe AM, Hegmann KT, Gren LH, Alder SC, White GL, Jr., Lyon JL. Associations between body-mass index and surgery for rotator cuff tendinitis. *The Journal of Bone and Joint Surgery, American Volume* 2004;86-A:743-747.

13. Gates DM, Succop P, Brehm BJ, Gillespie GL, Sommers BD. Obesity and presenteeism: the impact of body mass index on workplace productivity. *J Occup Environ Med* 2008;50:39-45.

14. Irving DB, Cook JL, Young MA, Menz HB. Obesity and pronated foot type may increase the risk of chronic plantar heel pain: a matched case-control study. *BMC Musculoskeletal Disorders* 2007;8:41.

15. Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. *Osteoarthritis and Cartilage / OARS, Osteoarthritis Research Society* 2010;18:24-33.

16. Wendelboe AM, Hegmann KT, Biggs JJ, et al. Relationships between body mass indices and surgical replacements of knee and hip joints. *Am J Prev Med* 2003;25:290-295.

17. Kohatsu ND, Schurman DJ. Risk factors for the development of osteoarthrosis of the knee. *Clinical Orthopaedics and Related Research* 1990:242-246.

18. Bagge E, Bjelle A, Eden S, Svanborg A. Factors associated with radiographic osteoarthritis: results from the population study 70-year-old people in Goteborg. *The Journal of rheumatology* 1991;18:1218-1222.

19. Felson DT. The epidemiology of knee osteoarthritis: results from the Framingham Osteoarthritis Study. *Seminars in Arthritis and Rheumatism* 1990;20:42-50.

20. Heuch I, Hagen K, Zwart JA. Body mass index as a risk factor for developing chronic low back pain: a follow-up in the Nord-Trondelag Health Study. *Spine* 2013;38:133-139.

21. Leino-Arjas P, Solovieva S, Kirjonen J, Reunanen A, Riihimaki H. Cardiovascular risk factors and low-back pain in a long-term follow-up of industrial employees. *Scandinavian Journal of Work, Environment & Health* 2006;32:12-19.

22. Miranda H, Viikari-Juntura E, Punnett L, Riihimaki H. Occupational loading, health behavior and sleep disturbance as predictors of low-back pain. *Scandinavian Journal of Work, Environment & Health* 2008;34:411-419.

23. Tubach F, Leclerc A, Landre MF, Pietri-Taleb F. Risk factors for sick leave due to low back pain: a prospective study. *J Occup Environ Med* 2002;44:451-458.

24. Van Nieuwenhuyse A, Crombez G, Burdorf A, et al. Physical characteristics of the back are not predictive of low back pain in healthy workers: a prospective study. *BMC Musculoskeletal Disorders* 2009;10:2.

25. Morken T, Moen B, Riise T, et al. Prevalence of musculoskeletal symptoms among aluminium workers. *Occup Med (Lond)* 2000;50:414-421.

26. Silverstein BA, Bao SS, Fan ZJ, et al. Rotator cuff syndrome: personal, work-related psychosocial and physical load factors. *J Occup Environ Med* 2008;50:1062-1076.

27. Miranda H, Viikari-Juntura E, Martikainen R, Takala EP, Riihimaki H. A prospective study of work related factors and physical exercise as predictors of shoulder pain. *Occupational and Environmental Medicine* 2001;58:528-534.

28. Luime JJ, Verhagen AP, Miedema HS, et al. Does this patient have an instability of the shoulder or a labrum lesion? *JAMA* 2004;292:1989-1999.

29. Roquelaure Y, Ha C, Rouillon C, et al. Risk factors for upper-extremity musculoskeletal disorders in the working population. *Arthritis and Rheumatism* 2009;61:1425-1434.

30. Nathan PA, Keniston RC, Myers LD, Meadows KD. Obesity as a risk factor for slowing of sensory conduction of the median nerve in industry. A cross-sectional and longitudinal study involving 429 workers. *J Occup Med* 1992;34:379-383.

31. Andersen RE, Crespo CJ, Bartlett SJ, Bathon JM, Fontaine KR. Relationship between body weight gain and significant knee, hip, and back pain in older Americans. *Obesity Research* 2003;11:1159-1162.

32. Bureau of Labor Statistics. Employment status of the civilian noninstitutional population, 1940 to date [Internet]. Available at: http://www.bls.gov/cps/cpsaat1.pdf.

33. Hymel PA, Loeppke RR, Baase CM, et al. Workplace health protection and promotion: a new pathway for a healthier--and safer--workforce. *J Occup Environ Med* 2011;53:695-702.

34. Bhanji S, Khuwaja AK, Siddiqui F, Azam I, Kazmi K. Underestimation of weight and its associated factors among overweight and obese adults in Pakistan: a cross sectional study. *BMC Public Health* 2011;11:363.

35. Mogre V, Mwinlenna PP, Oladele J. Distorted self-perceived weight status and its associated factors among civil servants in Tamale, Ghana: a cross-sectional study. *Archives of Public Health = Archives belges de sante publique* 2013;71:30.

36. Duncan DT, Wolin KY, Scharoun-Lee M, Ding EL, Warner ET, Bennett GG. Does perception equal reality? Weight misperception in relation to weight-related attitudes and behaviors among overweight and obese US adults. *The International Journal of Behavioral Nutrition and Physical Activity* 2011;8:20.

37. Jones M, Grilo CM, Masheb RM, White MA. Psychological and behavioral correlates of excess weight: misperception of obese status among persons with Class II obesity. *The International Journal of Eating Disorders* 2010;43:628-632.

38. Forman MR, Trowbridge FL, Gentry EM, Marks JS, Hogelin GC. Overweight adults in the United States: the behavioral risk factor surveys. *The American Journal of Clinical Nutrition* 1986;44:410-416.

39. Garg A, Hegmann KT, Moore JS, et al. Study protocol title: a prospective cohort study of low back pain. *BMC Musculoskeletal Disorders* 2013;14:84.

40. Garg A, Hegmann KT, Wertsch JJ, et al. The WISTAH hand study: a prospective cohort study of distal upper extremity musculoskeletal disorders. *BMC Musculoskeletal Disorders* 2012;13:90.

41. NHLBI Obesity Education Initiative Expert Panel on the Identification Evaluation and Treatment of Obesity in Adults (US). *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*. Bethesda (MD): National Heart, Lung, and Blood Institute; September 1998.; 1998.

42. Grossschadl F, Titze S, Burkert N, Stronegger WJ. Moderate- and vigorous-intensity exercise behaviour according to the Transtheoretical Model: associations with smoking and BMI among Austrian adults. *Wiener Klinische Wochenschrift* 2013;125:270-278.

43. Prochaska JO, DiClemente CC. Stages and processes of self-change of smoking: toward an integrative model of change. *Journal of Consulting and Clinical Psychology* 1983;51:390-395.

44. Prochaska JO, DiClemente CC, Norcross JC. In search of how people change. Applications to addictive behaviors. *The American Psychologist* 1992;47:1102-1114.

45. Greenwood JL, Murtaugh MA, Omura EM, Alder SC, Stanford JB. Creating a clinical screening questionnaire for eating behaviors associated with overweight and obesity. *J Am Board Fam Med* 2008;21:539-548.

46. De Vet E, De Nooijer J, De Vries NK, Brug J. Do the transtheoretical processes of change predict transitions in stages of change for fruit intake? *Health Education & Behavior: The Official Publication of the Society for Public Health Education* 2008;35:603-618.

47. Kim MS. Exercise stages of change among university students taking fitness and sport skills courses. *Perceptual and Motor Skills* 2010;110:1149-1153.

48. Kong W, Langlois MF, Kamga-Ngande C, Gagnon C, Brown C, Baillargeon JP. Predictors of success to weight-loss intervention program in individuals at high risk for type 2 diabetes. *Diabetes Research and Clinical Practice* 2010;90:147-153.

49. Marcus BH, Rakowski W, Rossi JS. Assessing motivational readiness and decision making for exercise. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association* 1992;11:257-261.

50. Marcus BH, Simkin LR. The stages of exercise behavior. *The Journal of Sports Medicine and Physical Fitness* 1993;33:83-88.

51. Verheijden MW, Van der Veen JE, Bakx JC, et al. Stage-matched nutrition guidance: stages of change and fat consumption in Dutch patients at elevated cardiovascular risk. *Journal of Nutrition Education and Behavior* 2004;36:228-237.

52. Zimmerman GL, Olsen CG, Bosworth MF. A 'stages of change' approach to helping patients change behavior. *American Family Physician* 2000;61:1409-1416.

53. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009-2010. *NCHS Data Brief* 2012:1-8.

54. Overweight and Obesity: Utah State Nutrition, Physical Activity, and Obesity Profile. Available at: http://www.cdc.gov/obesity/stateprograms/fundedstates/pdf/utah-state-profile.pdf. Accessed: April 20, 2014.

55. Paeratakul S, White MA, Williamson DA, Ryan DH, Bray GA. Sex, race/ethnicity, socioeconomic status, and BMI in relation to self-perception of overweight. *Obesity Research* 2002;10:345-350.

56. Wee CC, Davis RB, Phillips RS. Stage of readiness to control weight and adopt weight control behaviors in primary care. *Journal of General Internal Medicine* 2005;20:410-415.

57. Jakicic JM, Polley BA, Wing RR. Accuracy of self-reported exercise and the relationship with weight loss in overweight women. *Medicine and Science in Sports and Exercise* 1998;30:634-638.

58. Lichtman SW, Pisarska K, Berman ER, et al. Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. *The New England Journal of Medicine* 1992;327:1893-1898.

59. Employment Status of the Civilian Noninstitutional Population, 1940 to Date [Internet]. Available at: http://www.bls.gov/cps/cpsaat01.pdf. Accessed: September 2012.

60. Hymel PA, Loeppke RR, Baase CM, et al. ACOEM Guidance Statement. Workplace health protection and promotion: a new pathway for a healthier--and safer--workforce. *Journal of Occupational and Environmental Medicine/ American College of Occupational and Environmental Medicine* 2011;53:695-702.

CHAPTER 5

CONCLUSION

The combined prevalence of overweight and obesity of 77.9% among production workers was greater than expected. The prevalence of obesity alone (50.2%) among workers is greater than is reported for the U.S. adult population (35.7%), and is twice as high as a recently reported prevalence for U.S. workers (27.7%).[1]

Moreover, there were differences in factors associated with obesity between the two different cohorts which may be related to the type of work performed.

A review of the literature only identified two research studies which assessed predictors of obesity among production workers. Both of them used self-reported height and weight measures to determine BMI. In addition, both only looked at one occupation for their analyses. By contrast, using anthropometric height and weight measures in this research study eliminated recall bias as well as issues of exaggeration of leisure-time physical activity. In addition, this research filled a gap in the literature regarding production workers.

Results showed that most of the reported associations with increases in weight and TC levels are amenable to interventions and may be a target for workplace intervention programs. This study found the sole characteristic associated with weight gain over the study duration is a belief they are overweight or obese.

Characteristics associated with weight reductions included: consuming breakfast <6 times/week and baseline overweight and obesity. Characteristics associated with increases in TC levels over the study duration included: female gender, belief their TC levels were "not good," and feeling depressed. Characteristics associated with TC reductions included: having family problems and consuming breakfast <6 times per week. To our surprise, fast food consumption was not associated with weight or TC level changes, except for breakfast consumption.

Interventions may for example target increasing awareness of abnormal TC levels which may help correct misperceptions workers may have about these health indicators.

The combined prevalence of overweight and obesity of 77.9% in this working population is astonishing. The prevalence of obesity (50.2%) is greater than for the U.S. adult population (35.7%)[2] and is twice as high as a recently reported prevalence for U.S. workers (27.7%).[1] Considering an even lower prevalence of 22.5% for obesity in the state of Utah,[3] these production workers represent an important target population for weight loss interventions.

About half of overweight/obese workers were in the precontemplation or contemplation stages for healthy dietary changes or weight loss. We also found a substantial disconnect between workers' measured BMI and self-perceived BMI.

The finding of this research are concerning as they relate to risks for work-related musculoskeletal injury as well as obesity related chronic diseases and health care costs. Given the well documented impact of obesity on occupational illnesses, injuries, and overall increasing productivity costs, this research identified an important target population for interventions to improve weight and weight related comorbidities.

The Bureau of Labor Statistics estimates that the U.S. civilian workforce employed approximately 140 million people in 2009. [4] It is estimated that 65% of the adult population of the U.S. can be reached through worksites.[5] The workplace, therefore, may be an optimal location for workplace prevention programs in industrial facilities, targeted at weight loss interventions.

Different associations found between the cohorts may be useful to indicate the need of sector-specific strategies for health promotion and prevention of overweight. Future research is warranted to assess the role of job-related physical activity demands and obesity.

Recognizing the stages of change with regard to weight and the self-perception of weight status may help health professionals in the workplace to tailor workplace health promotion programs.

The lack of associations found between leisure-time physical activity levels outside of work and obesity, weight, and TC changes among workers were surprising. Further analyses supported our suspicion of workers heavily exaggerating their leisure-time physical activity. Future investigations are intended to further assess this issue by looking at a subset of our population for which accelerometer data are available. Corroboration with accelerometer data would not only allow quantification of the amount workers exaggerated their leisure-time physical activity, but also determine the usefulness of self-reported physical activity levels among production workers.

References

1. Luckhaupt SE, Cohen MA, Li J, Calvert GM. Prevalence of obesity among U.S. Workers and associations with occupational factors. *Am J Prev Med* 2014;46:237-248.

2. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009-2010. *NCHS Data Brief* 2012:1-8.

3. Overweight and Obesity: Utah State Nutrition, Physical Activity, and Obesity Profile. Available at: http://www.cdc.gov/obesity/stateprograms/fundedstates/pdf/utah-state-profile.pdf. Accessed: April 20, 2014.

4. Employment Status of the Civilian Noninstitutional Population, 1940 to date [Internet]. Available at: http://www.bls.gov/cps/cpsaat01.pdf. Accessed: September 2012.

5. Hymel PA, Loeppke RR, Baase CM, et al. ACOEM Guidance Statement. Workplace health protection and promotion: a new pathway for a healthier--and safer--workforce. *Journal of Occupational and Environmental Medicine/ American College of Occupational and Environmental Medicine* 2011;53:695-702.